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INDUSTRIAL QUALITY CONTROL

In This Issue

Electrical Component Analysis

Existing Computer Techniques

Multi-Factor Experiments

Binomial and Poisson Signifiance Tests

QUALITY through Scientific Methods

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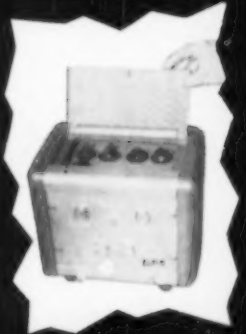

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INDUSTRIAL QUALITY CONTROL

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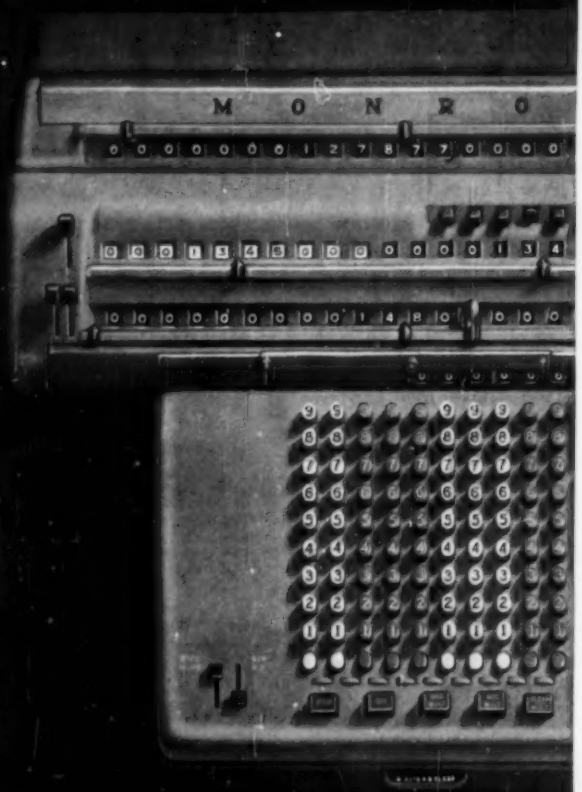

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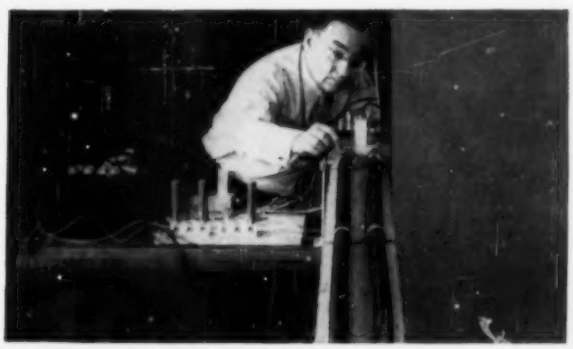

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No doubt you have already noted the new "face" for our journal. The new cover design, introduced with the January issue, is one result of the increasing efforts being put forth by the Editorial Board and the editorial staff to make *Industrial Quality Control* more attractive and useful to members of the Society. Special committees have just recently been appointed to continue a study of all phases of the journal with the view to recommending still further changes for the benefit of both the reader and the advertiser.

You have probably noticed, too, another new feature introduced recently—Product Education Service. It is encouraging to note the fine response to this new service; our advertisers are pleased with the inquiries they have already received concerning their products and services. To further this program, I urge you to take advantage of this service—it is readily available —and it may well save you time and money in your operations.

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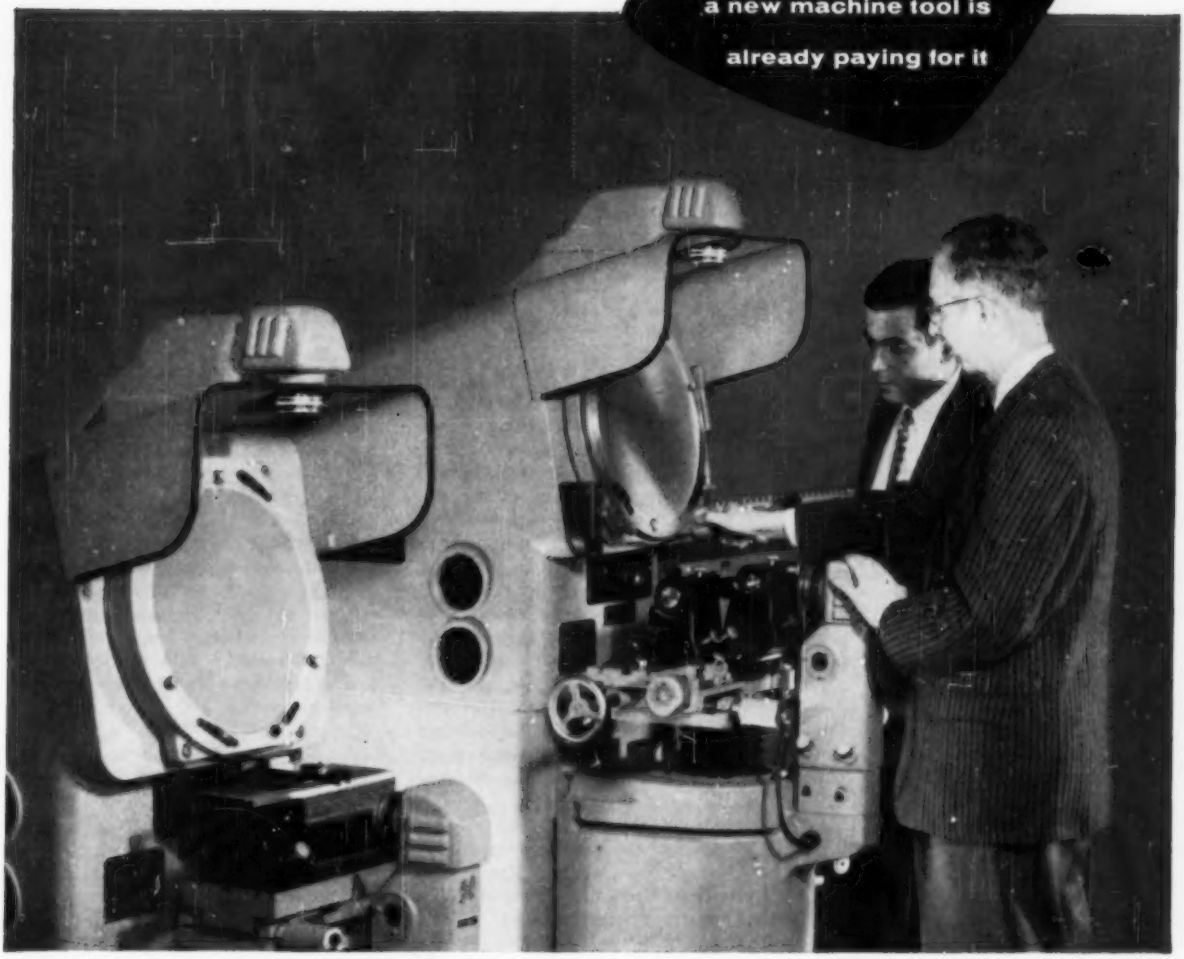

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A New Philosophy of

Electrical Component Acceptance

H. G. HARDING and R. A. HULNICK

Military Products Div., IBM Corp., Kingston, N. Y.

The Problem of Component Acceptance

At times, IBM and other companies have rejected electrical components that the vendor has passed as meeting specifications. At other times, companies have later accepted components initially rejected, or the vendor has condemned components that he originally considered acceptable. Such confusion has resulted in costly delays caused, specifically, by the following:

a. a high lot-rejection rate
b. a slowdown in production at IBM
c. resulting sorting operations (virtually 100 percent inspection)
d. reinspection procedures by vendors
e. time and expense consumed in travel and consultation.

This article will attempt to show that a solution to the problem of component acceptance does not require the use of new standards or techniques but rather a new philosophy in approaching the problem. Since application of this philosophy is not limited to IBM, the problem of component acceptance will be described as one between the vendor and consumer, rather than as a problem concerning only IBM.

An Elaboration of the Problem

In the past, there have been differences of opinion between consumers and vendors on the acceptability of certain lots of electrical components. The sources of these difficulties may be classified into three categories:

a. A difference in the calibration of the production test equipment used by the consumer and of that used by the vendor. This may be due either to different calibration procedures or different results obtained with the same procedures, or a combination of both. An irreducible discrepancy exists even when two units of identical laboratory test equipment are used. For example, the vendor's equipment might give a +1 percent accuracy while the consumer's gave a −1 percent accuracy.
b. A difference in the production test procedures or equipment, aside from calibration, used by the vendor.
c. Human errors.

These difficulties of the consumer and the vendor in correlating specifications is further aggravated by two considerations.

When the vendor's distribution of test values approaches either limit of a specification, acceptance or rejection seems the result of capricious choice rather than of precise determination. Many test meters read values in percent away from the nominal value. The meters cannot give definitive readings, which increases the tendency to reject components with borderline readings. If, for example, a resistor must meet a specified tolerance of ±5 percent with ±1 percent accuracy, a meter may show a value between 4.0 and 6.0 percent away from the nominal value, depending upon the calibration point. Incoming inspection, under these conditions may accept a resistor with a 6.0 percent tolerance away from the nominal value shown on a meter accurate to −1.0 percent or reject a resistor with a 4.0 percent tolerance away from the nominal value on a meter accurate to +1.0 percent. Such blurring of the tolerance line may result in the consumer rejecting a component passed by the vendor, or may result in either party reversing its initial decision on a second testing. Obviously, such confusion results in delays and increased costs.

There is a second consideration that increases the importance, as well as the difficulties, of uniform test readings. Since incoming in-

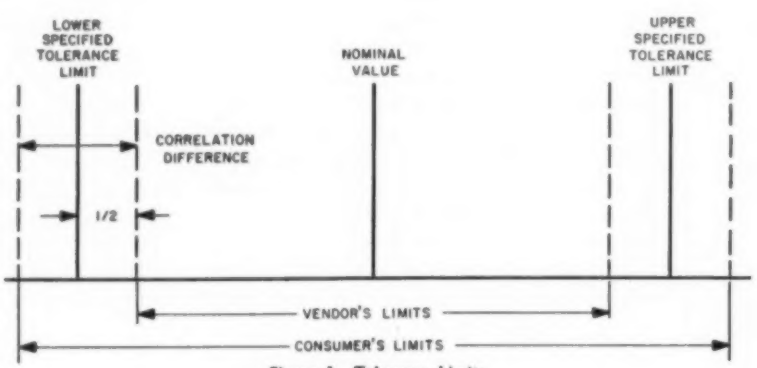

Figure 1—Tolerance Limits

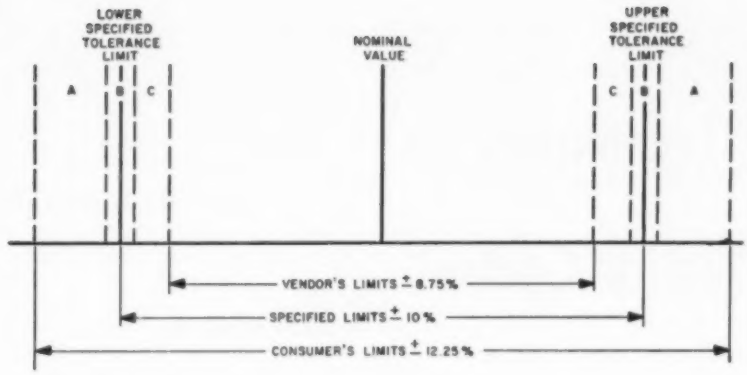

Figure 2—Components Tolerance Limits

spection uses sample rather than 100 percent testing, the importance of each acceptance or rejection is multiplied. The arbitrary acceptance or rejection of a few components will decide the disposition of an entire lot. Also, the tendency to reject components with borderline tolerances will be increased.

A Solution to the Problem

The first step toward the solution of the tolerance correlation problem is the acceptance of responsibility by both the vendors and the consumer. In order to solve this mutual problem, several recommendations are made.

The consumer and the vendors should evaluate their calibration equipment and procedures. By mutual consultation and agreement, the difference between their results should be reduced to an absolute minimum. Thus, −1 percent accuracy for both the consumer and vendor would be preferable to only one of the two having 0 percent error (100 percent accuracy).

Once this correlation difference has been reduced as far as possible, it should be divided equally between the consumer and the vendor. Thereafter, the vendor assumes that both specified tolerance limits of his product have been narrowed by one-half the correlated difference. The consumer, at the same time, will expand his own acceptance specifications by one-half this correlated difference. This mutual adjustment is illustrated in Fig. 1, which shows both the vendor's and the consumer's new tolerance limits.

Normal production testing does not warrant the utilization of high-accuracy laboratory apparatus such as that used to correlate test equipment. Therefore, compensation must also be made for the fallibility of the production test equipment. The relative inaccuracy of production test equipment requires the vendor to compensate by narrowing the tolerance limits specified to further than one-half the correlated difference described above. The consumer expands correspondingly his acceptance limits.

A consumer may order components, for example, for which the tolerance specified is ±10 percent. The most accurate laboratory apparatus available indicates a correlated difference in test equipment of approximately 0.5 percent. If the vendor's production test equipment is accurate to within 1.0 percent and the consumer's to within 2.0 percent (see Fig. 2), the vendor will conduct assembly-line testing to a tolerance of ±8.75 percent and the consumer will test for an acceptance tolerance of ±12.25 percent. Testing to these tolerances with this equipment, the vendor should never ship components with a tolerance higher than ±9.75 percent, and the consumer should never reject any with less than ±10.25 percent tolerance.

Conclusions

At least four vendors to IBM have cooperated, for the last 18 months, in the modification of acceptance practices, as described in this article. The problem of acceptable tolerances has been largely resolved. The previous high rejection rate of 4 percent has been reduced to an interim level of 2½ percent. The correction of the tolerance problem has completely eliminated rejections with two vendors. Since the adoption of this mutually agreeable, flexible standard, the quality limits set by production requirements have been met, much delay and expenditure have been eliminated, and the deterioration of IBM-vendor relationship has been prevented. The small percentage of component rejection that remains is not attributable to tolerance agreement or testing correlation problems, but to unknown factors now being investigated.

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Authors are invited to send manuscripts and correspondence concerning the series to Leo A. Goodman, Department of Statistics, University of Chicago, Chicago 37, Illinois.

The Role of Existing Computer Techniques in Statistics and Quality Control*

MERVIN E. MULLER

Princeton University, Princeton, N. J.

Introduction

Many problems encountered in physical applications and the real world may appear at first glance to be static; however, closer examination shows that several types of time dependence are involved. Our knowledge of a given physical process is a function of time. Certainly our analytical techniques and the possible equipment we employ to analyze a process are not static. Further, there exists a limit on the period of time we are permitted before it is necessary to draw some conclusions concerning a given problem.

Though we live in a dynamic world, it is remarkable how difficult it is for us to overcome the inertia we meet from within ourselves and others when we try to change old habits or methods of approach to problems. It is important to acknowledge that the techniques we employ now to analyze and solve problems may have the same value in a few years that the oil reading lamps of yesterday have today. However, we should not overlook the fact that the oil lamps did light the way in their day.

Computers have much to offer the statistician who must now accept the challenge they present and take an active role in directing their use.

An important role of the electronic computer is to allow one to carry out and evaluate experimentation on an improved time scale. Further, and possibly even more important, we now can have calculations carried out by electronic computers with a level of precision and reliability that was never before obtainable. It may come as a surprise to some that high speed computers are more reliable than humans, but experience of the past several years bears this out. In fact, the freedom from error of the latest electronic computers is enormously better than that of any previously known method of computation.

Areas where electronic computers can make positive contributions today in the field of statistics and statistical quality control are: (1) Administrative Control, (2) Data Processing, (3) Technical Computations and (4) Simulation Research. In this article the author attempts to give a general outline of some of the applications of computers to these areas, quoting specifically the particular programs with which he is most familiar.

Administrative Control

In a process that involves the development of a sequence of instructions which humans are to execute, we have a situation where a computer can be of service by creating the instructions. For lack of a better term let us call this function of computers *Administrative Control.*

In many respects, to consider this topic first is to put the cart before the horse. For the moment let us do exactly this; let us assume that we know precisely what technical tools are needed to analyze a problem. For example, imagine we are concerned with sampling inspection of some manufacturing process. We need to make available a complete set of detailed instructions for the necessary inspection. The obvious application of the computer is the preparation of acceptance or rejection tables. However, we should not imagine that the usefulness of such a machine stops at this point. Computers can be used for administrative control itself.

Once having decided which manufacturing process is to be inspected, and which statistical technique is to be employed, the necessary program can be selected from the library of administrative control programs and initial information such as starting and completion dates, nature of the desired outgoing quality characteristic curve, and the like specified. The computer can then go to work and produce the necessary printed information, even including who is to receive the instructions and work procedures. In addition to gaining speed we have more comprehensive and more reliable control by using a computer in this way. To depend on humans alone makes for errors of omission. It is easy to forget to include part of the specifications or to omit to notify some of the departments concerned.

In many quality control problems, such as the inspection of components of an assembly, the entire manufactured item is not inspected. Instead, a random or systematic sample of the components is taken. The decision as to which components are to be sampled during a given time period can be based on several criteria. In many situations the manufactured product can be thought of as consisting of k sets of components, s_1, s_2, ..., s_k, where there are n_i items in the s_ith set. For instance, the sets might be sub-assemblies. Based on relative costs or importance of these sets of components, it may be decided to inspect them in the proportions p_1, p_2, ..., p_k, where the only restriction of the p_i's is that $p_i \geq 0$ and $\sum_{i=1}^{k} p_i = 1$. In order to have a sample of L components of this system satisfying these conditions, we have to arrange that a set s_i is selected p_i percent of the time, either exactly or on the average.

The role of the computer is first to select the appropriate set s_i and then to take a sample from it at random. For any desired size sample, the process of deciding which items to inspect, say for a specific day, and the subsequent preparation of the inspection instructions creates an ideal application of modern stored programmed computers. (The details of how to develop

*Presented at the Thirteenth Annual Princeton Conference of the American Society for Quality Control and sponsored by the Office of Ordnance Research, U. S. Army; Statistical Techniques Research Group, Princeton University, Contract No. DA-36-034-ORD-2297.

this specific machine procedure are considered in the Appendix.)

Data Processing

Record keeping of information, such as of machine failures, whether regarded as a problem in administrative control or of data processing, can be most efficiently carried out on a computer. We may, for example, want to keep track of the way in which certain components are being used, how often a certain bearing has to be packed, or to be informed when the number of packings in some specified time period exceeds a given level. Or again, maybe we want to know if the number of simultaneous failures of two components exceeds a specified level. A computer easily keeps account of such information. As a further example of this type of application the up-dating and examination of inspection or field records may be quoted. Again, we gain speed and reliability.

The introduction of electronic computers into data processing does away with much time-consuming drudgery and allows one time to reflect about the real problems. We have time to ask such questions as "What use should be made of these data?" Since an analysis which might have taken months can now be done within a few hours, or even minutes, a person who suggests that a certain set of data be collected may be expected still to be around after the analysis has been done. This makes for more responsible planning.

Another application is on the verification of data. It is pointless to perform an analysis with faulty data, yet faulty data are surprisingly common. If the amount of data collected for a given problem is at all extensive, it becomes almost impossible to check it by direct verification. Computer techniques for checking are in their infancy but computers clearly have much to offer in the solution of this problem which continues to receive study.

For certain problems, such as those where the data should come into the computer in a monotone fashion, it is easy to use the machine to check for gross errors. For instance, in the analysis of length of life of a given manufactured product the number of items still in use should decrease with time and we can easily have the computer test the data to see that the number of items still functioning at any time is not greater than reported previously. Again, if we are analyzing failure rates, we can test the data to ensure that the number of failures recorded does not exceed the total number of items in use during that period. While the tests mentioned still allow errors to be present in the data, they represent a step in the right direction and are exceedingly easy to carry out on available machines. Another interesting suggestion is to put the data into the machine and use the computer to make a series of quality control tests before accepting them. Machine programs are just beginning to appear for the preparation of various frequency breakdowns and the calculation of elementary summary statistics. For example, an IBM 704 program to perform a complete and simultaneous frequency breakdown on ten indices has been undertaken and should be available in the near future.

Technical Computations

Here many machine programs are now available. In some cases the application of existing ideas has had to wait until the development of computers of sufficiently high speed; other problems have for some time been treated on medium and small size machines.

There are numerous curve-fitting routines which use the method of least squares to fit the data to the hypothetical model assumed to be represented by a particular type of function.[P1]* Examples of such programs are those which fit all polynomials up to some specified degree, allowing the deviations of the data from the model to be arbitrarily weighted.

An aspect of curve-fitting which is usually not adequately treated is the analysis of residuals. This has been neglected in the past partly because the calculation of residuals was too time-consuming. Analysis of residuals may be used, not only to indicate in what way the model is inadequate, but also to help locate errors in the data. In both these applications high-speed computing equipment clearly plays an important part.

For moderate sized linear regression problems involving, say, eight independent variables with several hundred observations, a medium sized computer can obtain estimates of the parameters for a specific linear regression model and their variance-covariance matrix[P2] in a matter of minutes, while a large computer requires only a few seconds. As an essential part of one program[P3] one obtains not only residuals but also a frequency distribution of the residuals and its extreme values. Even if the problem involves fifty variables and several thousand observations, one can obtain answers from a large machine in less than nine minutes. It is clear, therefore, that even the largest linear regression problems can be handled with ease with modern machine techniques.

When the data are orthogonal, a tremendous simplification in the calculations is possible. Although, for larger problems, it would be uneconomic to ignore the simplification resulting from orthogonality, in some cases where the number of variables is small it may not be worth while to have a special program to deal with the orthogonal case. For example, a factorial experiment involving ten factors at three levels leads to a matrix of independent variables of order one thousand. In examples of this sort it is clearly worth while to take account of the special nature of the matrix.

On the other hand, in some response surface problems where there will usually not be more than six variables and not more than fifty to a hundred observations, the increase in speed and the saving in memory space resulting from taking account of orthogonality is of minor importance compared with the convenience of having a general program. Similarly, although any analysis of variance procedure may be looked upon as a special case of regression analysis, a computer approach from this direction is not necessarily best.[P4,P5]

When the data have come, for example, from production records and are not orthogonal, the problem of finding the variables which account for the majority of the variation is of importance. To aid in the search for the best "explaining variables," computer programs have been devised which perform the linear regressions in all possible orders. The computer calculates the sum of squares which could be accounted for by regression using the variables in all possible ways, two at a time, three at a time, etc.

When the experimental conditions which are to be run are planned in advance with the object of elucidating important features of the relationship between the response and the variables, we enter the area of response surface methodology. The computations arising from the problems using this technique are just beginning to receive attention and electronic computers have an important role here. A computer program is de-

*Refers to list of computer program references which appears at the end of the article.

scribed in one of the references[B1,2] which calculates a fitted second degree equation in the k variables for any selection of experimental points, whether corresponding to a special design or not. The data corresponding to each separate trial are associated with a single card on which are punched the levels of the variables and the values of the responses observed in this particular trial. This makes it possible to make use of analyses omitting certain experiments or weighting certain experiments more heavily than others. Weighting can be done very simply by introducing the data from the more heavily weighted experiments more than once with replicate cards.

Of very great importance in understanding the nature of the fitted surface is the method of canonical analysis which is part of the problem of selecting coordinate scales and transformations. Computers can perform such transformations with ease. Considerable development of this phase can be expected. Some of the problems of multifactor least squares have already been programmed and routines are available to determine linear discriminants and perform factor analysis.

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Another area which is proving to be of great importance is that of time series analysis. Programs exist and are in use[P7] for finding moving averages and also for determining normalized serial correlations for various lead-or-lag intervals, resulting in estimates of noise spectra.[P8] Important problems whose solution involves to some extent response surface methodology, time series analysis, and servo mechanism theory arise in Evolutionary Operation and automatic optimisation.[B2,B3] These are beginning to be studied and provide a fruitful field for the use of highspeed computers.

It is said that a picture can express a thousand words, and a valuable but perhaps not widely known use of computers is in the preparation of graphs, diagrams, and plots of data.[P9]

Simulation Research

Experimentation is usually thought of as the natural tool of chemists, physicists and the like. However, it is coming to be realized more and more that close analogy between efficient numerical methods and efficient experimentation exists, and in recent years there has been increased interest in simulation techniques, empirical sampling, and Monte Carlo Methods. In these methods, given some specific model, the computer performs what corresponds to an experiment and uses the results in the subsequent analysis in much the same way that experiments are used in science. As might be expected, in view of the close analogy with experimentation, many of the principles of experimental design must be taken over in order to ensure efficient computation. The techniques are not new but are very time consuming and were largely impracticable until the very high speed of computation obtained with modern methods became available. Of course simulation techniques are sometimes abused, since they are resorted to when a more penetrating analysis of the problem would be obtained from standard mathematical analysis. However, they have a very important role in providing answers to problems where mathematical analysis is difficult or impossible.

In statistics, the use of these techniques has received further impetus with the availability of high-speed machines. The properties of most statistical procedures are only fully known in very limited circumstances, for example when the observations are normally distributed, have the same variance, and are independent. The use of empirical sampling methods makes it possible to study the behavior of the distributions of estimators, the power of tests, and the nature of loss and cost functions in any given conditions whatever. To quote a specific example, the late Professor Wald provided approximations for the average sample sizes and power functions of sequential tests. The author has recently studied a particular class of sequential tests and found considerable differences from what would have been expected by using Wald's approximations for the average sample sizes and power functions.

As a further example we may mention problems of "goodness of fit". The widely used Chi-square provides an overall "portmanteau" test in this situation. In specific circumstances when the type of alternative hypothesis which is to be guarded against is approximately known, tests having much better properties for this particular class of alternative can be devised. They have, however, so far received little attention because of difficulties associated with determining their distributions. Empirical sampling methods are making it possible for these new tests to receive the attention they deserve.

As a final example, consider the problem of relating y to x when the basic model is assumed to be linear. The problem has a simple solution if the assumption is made that all the errors are in y. When both variables are subject to error, however, the situation is very complex and simulation by a computer could be expected to be very fruitful.

Many complex problems arise in quality control which may be solved by the use of simulation techniques. Examples occur in machine maintenance. Using past histories of machine failures, manpower difficulties, and plant repair capacities, one may, by developing models and performing simulations, achieve considerable insight into how this mechanism behaves under various combinations of equipment, manpower, and repair facilities. In examples of this sort, again, it is important to remember that to ensure efficiency in convergence the computer "experiment" must be properly designed.

Conclusion

In the history of civilization, the introduction of such concepts as Arabic numerals and the associated methods of calculation has been the start of great advances, since it has liberated the intellect and allowed it to be used on new problems. The coming of electronic computers is an event of this order of importance. We can, for the first time, look forward to solving problems unimpeded by the very serious restriction that the volume and complexity of calculation is overwhelming.

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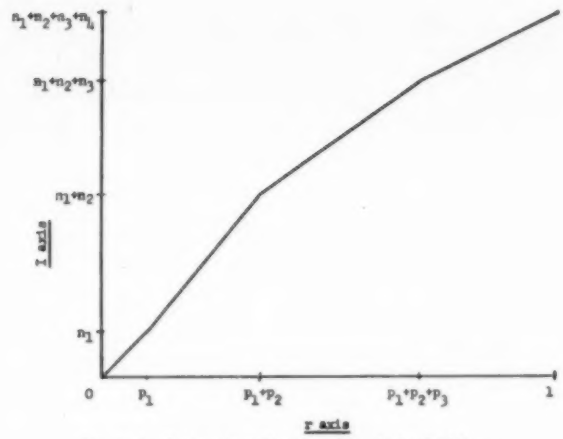

Figure 1—Geometrical Presentation of the Problem

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Appendix

Consider a system S containing N components which are classified into k sets $s_1, s_2, \ldots, s_k$, where the i^{th} set, s_i, has n_i components and $\sum_{i=1}^{k} n_i = N$. It is desired to inspect L components. Furthermore, it is desired to select a random sample for inspection such that within each set any component has the same chance of being chosen and the sample will contain Lp_i components, either on the average (plan 1) or exactly (plan 2) from the i^{th} set where $p_i \geq 0$ and $\sum_{i=1}^{k} p_i = 1$. For convenience, and without any loss in generality, it can be assumed that the items of S are numbered consecutively from 1 to N.

Given N, L, $s_1, s_2, \ldots, s_k$ and $p_1, p_2, \ldots, p_k$, a sample can be specified as follows:

1. Select a "random number", say r, between (0, 1). *Note:* satisfactory procedures and machine programs exist for the machine generation of pseudo-random numbers.*
2. Given the random number r, test to see which sub-interval it belongs to, where the sub-intervals are $(0 \leq r < p_1)$, $(p_1 \leq r < p_1 + p_2)$, ..., $\left(\sum_{i=1}^{k} p_i \leq r \leq 1\right)$.
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$$I(r) = (a_i + b_i r) + 1$$

where ( ) denotes the largest integer in $a_i + b_i r$ and

$$a_i = \sum_{j=0}^{i-1} n_j - b_i \sum_{j=0}^{i-1} p_j$$

$$b_i = n_i / p_i$$

and

$$n_0 = p_0 = 0$$

4. To obtain Plan 1 repeat steps 1 through 3 L times.

*O. Taussky and J. Todd, "Generation and Testing of Pseudo-Random Numbers," *Proc. Gainesville Monte Carlo Symposium*, John Wiley & Sons, Inc., 1956, p. 15-27.

5. To obtain Plan 2 repeat steps 1 through 3 until there are exactly Lp_i selected from each of the k sets. *Note:* as soon as a set is filled, additional items are rejected.

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General References

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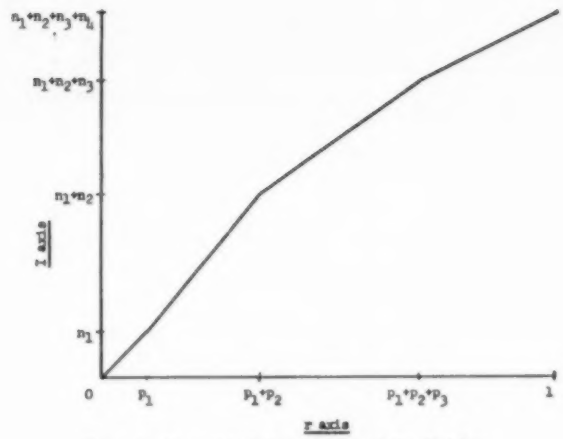

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Multi-Factor Experiments

the why's and wherefor's of planning experiments to permit proper data evaluation

M. ZELEN and W. S. CONNOR

National Bureau of Standards, Washington, D. C.

This article is concerned with the planning of experiments to investigate the joint effects of several factors on the performance of a piece of equipment, on the yield of a product, or on the characteristics of a test method. A considerable advantage is gained if the experiment is conducted so that the effects of changing each variable can be evaluated jointly with the effects of changing the other variables. One way of achieving this objective is to decide on a set of conditions for each factor and to carry out one or more measurements for every possible combination of the conditions. Such experiments are termed factorial experiments or multi-factor experiments.

Early applications of the formal theory of factorial experimentation were to the special problems of agricultural research. Here, the agricultural scientist planted in the spring, harvested in the fall, and used the entire winter for analyzing the results. Somewhat later, efforts were made to adapt these experimental procedures for use in the physical and engineering sciences. The recent growth of the subject of the statistical design of experiments has occurred in response to the need for methods specially suited to these new areas of applications.

Among the difficulties commonly encountered with the application of factorial experiments is that the total number of different combinations of conditions may be quite large and in many cases prohibitive. In the physical and engineering sciences another disadvantage is that in many experimental situations it is not practical to plan an entire experimental program in advance. It may be better to conduct a few smaller experiments to serve as a guide to further work. This latter condition is especially true when measurements are made singly or in small groups, so that the experimental results become known sequentially as they are taken. In response to these disadvantages, ways of conducting factorial experiments have been developed which require a subset of measurements selected from all possible combinations. These reduced factorial experiment plans are called fractional factorial experiment plans or fractional replicates. The key idea behind fractional replication is to choose a sub-set from all possible combinations such that the sub-set chosen (i) contains as much or more relevant information than any other sub-set and (ii) the analysis is easy and straight-forward. An early account of fractional replication has been given by Finney.[5]

Recently, a publication entitled "Fractional Factorial Designs for Factors at Two Levels,"[1] prepared by members of the Statistical Engineering Laboratory of the National Bureau of Standards, appeared in print. This publication is a catalogue of fractional factorial experiment plans covering a wide range of experimental situations. The fractional plans in this catalogue are for situations covering from 5 through 16 factors and enable fractions of ½, ¼, ⅛, ..., 1/256 of a full experiment to be chosen. It is the purpose of this article to discuss fractional experimentation and to describe these fractional factorial plans. However, before describing fractional experimentation, we would like to discuss some of the basic concepts involved in complete factorial experimentation.

An example of a simple factorial experiment is provided by an experiment recently conducted at the National Bureau of Standards. This experiment was concerned with evaluating the strength of steel with respect to

A: Carbon Content
B: Tempering Temperature
C: Method of Cooling.

Part of this experiment consisted of considering two different conditions for each of the three factors. It will be convenient to designate these three factors by the letters A, B, and C. Also we shall denote one of the particular conditions at which a factor is evaluated by

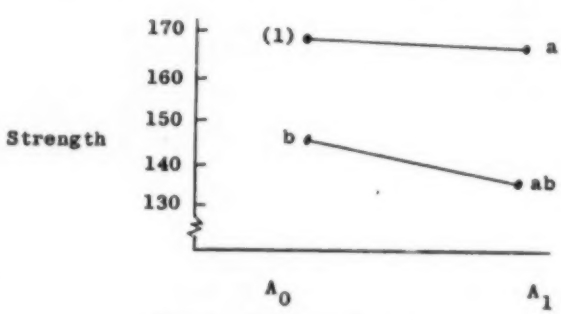

Figure 1—Measurements at C.

TABLE I—Results of Experiment

		A_0	A_1	
B_0	C_0	169	167	
	C_1	173	165	A = Carbon Content B = Tempering Temperature C = Method of Cooling
B_1	C_0	145	135	
	C_1	143	134	

the sub-script 0 and the other by a subscript 1. For example the two tempering temperatures involved were 400° F. and 600° F. These are represented by the symbols B_0 and B_1, respectively. Statisticians refer to the different experimental conditions of a factor by the term *level*. Thus each of the factors in this experiment has two levels, and the experiment is termed a 2^3 factorial experiment. Often we refer to the level with the 0 sub-script as a "low-level" and the level with the 1 sub-script as the "high-level" of a factor. Table I contains the experimental results for the eight possible factorial combinations.

These results* (coded for easy presentation) represent the strengths of eight steel specimens after a given period of stress.

Now in designating each of the eight factorial combinations, it will be convenient to use the notation of Table II. Note that the notation is such that if the level of a particular factor is at the low level, the letter is missing; if at the high level, the letter appears. The combination where all three factors are at the low level is simply designated by the number (1).

Figures 1 and 2 graph the results of the experimental results where Fig. 1 refers to the four measurements made at the C_0 condition and Fig. 2 refers to the four measurements made at the C_1 condition. In each of these graphs, strength is plotted against the carbon content. The lines join points which have the same level of tempering temperature. Thus, the line joining (*1*) and *a* in Fig. 1, connects two points having condition B_0. Similar interpretations hold for the other lines.

Now suppose we wished to evaluate the change of strength resulting from considering the two different carbon contents. Since the carbon factor is represented by A, we measure the effects of a change in strength with respect to a change in carbon content by the slopes of the four lines shown in Fig. 1 and 2. If the slopes are near zero, then we are justified in stating that the effect of a change in carbon content on strength is small over the range of the experimental conditions encountered here. It is an easy matter to calculate the slopes for each of the four lines. If we regard the difference in carbon content as a unit difference, then the slope is equal to the difference of the two points joined by each line. For example, for condition B_0 C_0, the slope is

$$a-(1) = 167-169 = -2.$$

*The numbers given are in lbs. per sq. in. divided by 10^3.

TABLE II—Notation for Factorial Combinations

Combination			Designation
A_0	B_0	C_0	(1)
A_1	B_0	C_0	a
A_0	B_1	C_0	b
A_1	B_1	C_0	ab
A_0	B_0	C_1	c
A_1	B_0	C_1	ac
A_0	B_1	C_1	bc
A_1	B_1	C_1	abc

We have four such slopes

$$\begin{aligned} a-(1) &= 167-169 = -2 \\ ab-b &= 135-145 = -10 \\ ac-c &= 165-173 = -8 \\ abc-bc &= 134-143 = -9 \\ \text{Average} &= -7.25 \end{aligned}$$

Each of these slopes represents the change in strength with a change in carbon content, holding the other factors fixed. Now if one wanted the average change due to carbon content over the range of conditions of this experiment, one would simply take the average of the four slopes. which is −7.25. Similar calculations can be made for the remaining two factors. These results are summarized in Table III. Statisticians usually refer to average slopes as *main effects*.

An outstanding advantage of factorial experiments is that the precision with which each main effect is measured is as good as if the experiment were devoted to measuring only that effect. Thus, the present factorial measures each of the main effects as precisely as would four-fold repeated runs, in which only one factor was varied.

From Table III it is easy to see that, in general, factor B (tempering temperature) produced the most change in strength. Factor C produced almost a trivial change in strength. Now suppose we wished to evaluate the inter-dependence of the effects of factor A and factor B. Does the effect of carbon content on strength depend upon the tempering temperature? One way of answering this question is, for fixed C, to compare the two slopes for factor A at condition B_0 with the slope

TABLE III—Average Slopes

Factor	Formula	Value
A	$\frac{1}{4}\{[a-(1)]+[ab-b]+[ac-c]+[abc-bc]\}$	−7.25
B	$\frac{1}{4}\{[b-(1)]+[ab-a]+[bc-c]+[abc-ac]\}$	−29.25
C	$\frac{1}{4}\{[c-(1)]+[ac-a]+[bc-b]+[abc-ab]\}$	−0.25

for factor A at condition B_1. In other words, looking at Fig. 1, which represents the four measurements made at condition C_0, we would like to ascertain whether the two lines are parallel. If they are parallel, this will indicate that the change due to factor A is independent of factor B and we may say that factor A does *not* interact with factor B. A similar comparison can be made for Fig. 2 which represents the four measurements made with C_1.

The two slopes on Fig. 1 are

$$\begin{aligned} \text{slope at } B_1\text{: } ab-b &= -10 \\ \text{slope at } B_0\text{: } a-(1) &= -2 \\ \text{difference} &= -8 \end{aligned}$$

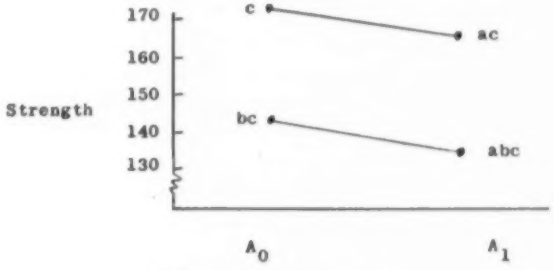

Figure 2—Measurements at C_1

For Fig. 2, the two slopes are

$$\text{slope at } B_1\text{: } abc-bc = -9$$

$$\text{slope at } B_0\text{: } ac - c = -8$$

$$\text{difference} = -1$$

If the lines are parallel, we expect the differences to be near zero. Again, as with the average slopes, we may take the average of these two differences to represent the average dependence of the effect of factor A on the levels of factor B. This average is −4.5. Similar calculations can be made for the two-factor interactions AC and BC. These are shown in Table IV. When these average differences are divided by two, statisticians term the result a *two-factor interaction*.

The largest interaction appears to be that between the factors A and B.* It is worth pointing out that in cases where the slopes are not parallel, it may sometimes be possible to achieve parallelism by an appropriate change of scale for the measured quantity. For example, in the ideal gas law, pv=RT, the volume-pressure curves are not parallel for different temperatures. However, by converting to logarithmic scales we achieve parallelism in the volume-pressure curves at various temperatures.

Note that the formula in Tables III and IV are made up of linear functions of the observations, divided in one case by four, and in the other case by two. For purposes of comparison, we can dispense with these divisors. Table V brings together all the appropriate formulas without divisors.

The quantities associated with the single letters A, B, and C are multiples of the main effects (or average slopes). These measure the trends produced by the various factors. The quantities associated with pairs of letters are multiples of the two-factor interactions (or the average differences in slope). These measure the dependence of the effects of pairs of factors on each other. By generalization, one can define a three-factor interaction which is presented (without the divisor) in Table V. Also, if more factors were involved, we could define four-factor, five-factor, and other higher-order interaction terms. In this article we confine our attention to main effects and two-factor interactions because the higher order interactions do not appear to arise often in applications.

TABLE IV—Average Differences Between Slopes

Interaction	Formula	Value
AB	½{[ab−b] − [a − (1)]} + [(abc−bc) − (ac−c)]	−4.5
AC	½{[ac−c] − [a − (1)]} + [(abc−bc) − (ab−b)]	−2.5
BC	½{[bc−c] − [b − (1)]} + [(abc−ac) − (ab−a)]	−2.5

Now suppose we were in the situation of wanting to select half of the eight combinations for experimentation. For this purpose, let the four measurements selected for the half-fraction be those having a minus (−) coefficient in the ABC interaction. These are

(1), ab, ac, bc.

If we were to run this half-replicate experiment, in addition to a loss in precision arising from taking a smaller number of measurements, another penalty involved would be that the estimates of the main effects and interactions would be entangled or "aliased" with one another. For example, referring to Table V, we can subtract the formula for the interaction BC from that for the main effect A. This gives an estimate for A-BC which only involves the four measurements used in the half-replicate. This formula appears in the bottom half of Table V. We say that the main effect A and the two-factor interaction BC are aliases of each other. There is no way of separating the two using these four measurements. However, if from *a priori* reasons, we could consider the BC interaction to be zero or negligible, then we could interpret A-BC as reflecting principally the main effect A. Similar quantities can be calculated for B-AC and C-AB which appear in the lower part of Table V.

Previously we pointed out that the measurements selected for the half-replicate were those which appeared with minus (−) coefficients in the ABC interaction. We usually indicate this by I = ABC. This quantity is called the fundamental identity. It can be used for selecting the fractional replicate and also for determining the aliases of all main effects and interactions. The factorial combinations were simply those combinations having an even number of letters in common with the fundamental identity, i.e., (1), ab, ac, bc.

In order to determine the aliases of any factor, we multiply both sides of the fundamental identity by that factor. For example, for the main effect A we have

$$A \cdot I = A^2BC$$

and using the convention

$$A \cdot I = A, \qquad A^2 = 1$$

we have A = BC and state that A is aliased with BC.

This discussion of aliases points up the dangers inherent in a small scale experiment. If two-factor interactions exist, it is desirable to have enough factorial combinations to permit the separate estimation of the main effects and the two-factor interaction effects. Or if three-factor interactions exist, still more factorial combinations are needed.

TABLE V—Main Effects and Interactions

	(1)	a	b	ab	c	ac	bc	abc	Value
A	−	+	−	+	−	+	−	+	−9
B	−	−	+	+	−	−	+	+	−117
C	−	−	−	−	+	+	+	+	−1
AB	+	−	−	+	+	−	−	+	−9
AC	+	−	+	−	−	+	−	+	−5
BC	+	+	−	−	−	−	+	+	−5
ABC	−	+	+	−	+	−	−	+	7
A-BC	−2	0	0	+2	0	+2	−2	0	−24
B-AC	−2	0	0	+2	0	−2	+2	0	−112
C-AB	−2	0	0	−2	0	+2	+2	0	8

These principles represent the basic aspects of fractional factorial experimentation. For any particular fraction, there will be many different fractional designs. The National Bureau of Standards designs have been constructed on the premise that the most important information needed is that associated with main effects; the second most important information is that on two-factor interactions. The NBS designs were made up so that no main effects are aliased with each other nor with two-factor interactions. If a two-factor interaction is aliased only with three-factor or higher-order interactions, the interaction is called a *measurable* two-factor interaction. It was attempted to construct the designs to attain the maximum number of measurable two-factor interactions.

*If this same experiment were run again and the same calculations were made, we would expect somewhat different numerical results from those presented in Tables III and IV. Such different results are due to the random errors inherent in the experiment. Therefore in order to decide objectively whether certain apparent effects among the factors are real, one would have to compare the numerical results with a measure of random errors. There are many statistical techniques for carrying out such comparisons. These are somewhat beyond the scope of this paper. Cf. Cochran and Cox,[2] Daniel,[3] Davies,[4] Kempthorne.[6]

Table VI gives the information needed for carrying out a ⅛ fraction of an experiment involving eight factors such that each factor is at two levels. The full factorial requires $2^8 = 256$ different combinations. The ⅛-fractional design needs only 32 measurements. The 32 selected measurements are given in eight columns.

The fundamental identity for this plan is associated with the letter I as before. However, because this is a ⅛ replicate, $2^3 = 8$ terms (including I) appear in the fundamental identity. Thus, every main effect and interaction will be aliased with seven other interactions. Of the 28 possible two-factor interactions, exactly 13 are measurable. The interpretation of the remaining 15 two-factor interactions is not clear cut as these contain aliases which have two-factor interactions.

Often the measurements or the experimental material may come in homogeneous groups. These homogeneous groups of measurements are called *blocks*. For example, quite often only a limited number of measurements can be made in one day. In this case, the measurements made on a single day would represent a block of measurements. Then if measurements made on a single day show better agreement with each other than measurements from different days, we would like to take this into account in our experimental plan so as to balance the day-to-day variation. These fractional plans have been constructed so as to take this situation into account. The eight columns in this ⅛ replicate show how one would assign the measurements to the days. The particular measurable two-factor interactions available, if blocking is used, are listed alongside the heading *Blocks only*. Here we still have 13 measurable two-factor interactions. On the other hand, even if we take into account differences between blocks, the order within a block might also be important. This would be the case if the measuring equipment were subject to a drift during the day. If the pattern of the drift were the same from day to day, the effects of the drift could be eliminated by making the measurements in the order indicated within the blocks. This has been provided for in many of the layouts.

Now we would like to say a few words about sequential experimentation. In some situations we might run our experiments in parts so that at the end of any part of the experiment we can go back and easily analyze the data. For example, we might run a 2^8 experiment in sets of 32 measurements. That is, we can run a ⅛ fraction, analyze it; if conditions warrant, run another ⅛ fraction to give a ¼ replicate, etc. Another possibility is to add on, or drop, one or more factors after a fraction has been completed.

This catalogue is for experiments where all factors are at two levels. However, by an easy modification they can be used for experiments where all factors are at four levels, or in general, for experiments where the numbers of levels are all powers of two. Also, sometime later this year another catalogue of fractional designs for factors at three levels will be published by the National Bureau of Standards. It is hoped that the publication of these catalogues of fractional designs will make the application of fractional experimentation more immediately accessible to the applied statistician and the working scientist.

TABLE VI—⅛ replication of 8 factors in 8 blocks of 4 units each

Factors: A,B,C,D,E,F,G,H.
I = ABEGH = ACFG = BCEFH = ABCD = CDEGH = BDFG = ADEFH.
Block confounding: EGH,FG,EFH,BEH,BG,BEFGH,BF.
Row confounding: ABEF,ACE,BCF.
Completely randomized: The following two-factor interactions are measureable: AE,AH,BE,BH,CE,CH,DE,DH,EF,EG,EH,FH,GH.
Blocks only: The following two-factor interactions are measurable: AE,AH,BE,BH,CE,CH,DE,DH,EF,EG,EH,FH,GH.
Blocks and rows: The following two-factor interactions are measurable: AE,AH,BE,BH,CE,CH,DE,DH,EF,EG,FG,GH.

Blocks			
1	*2*	*3*	*4*
(1)	abcd	acfg	bdfg
abcdefg	efg	bdeh	ace
abcdfgh	fgh	bdh	ach
eh	abcdeh	acefgh	bdefgh
5	*6*	*7*	*8*
cdefh	abefh	adegh	bcegh
abgh	cdgh	bcfh	adfh
abeg	cdeg	bcef	adef
cdf	abf	adg	bcg

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What's the Story About Cleveland?

THIS IS THE STORY ABOUT CLEVELAND, your host city and what it offers to you, its guests, when you attend the ASQC convention here, May 25-27.

The Cleveland of today is a big, busy city—Ohio's first and the nation's seventh. It is nothing like the spot along Lake Erie and the Cuyahoga River that General Moses Cleveland surveyed in July, 1796. This spot now is a city of more than a million people, the capital of a great trade empire, and an industrial giant ranking with the greatest in the world.

As a place to gather, Cleveland offers many attractions and points of interest. It is perhaps more noted as a cosmopolitan community than any similar metropolis its size because of its heterogeneous population. The city, whose metropolitan area stretches out from the Lake Erie shoreline like a fan, is particularly known for its fine cultural institutions and civic spirit and in 1946 celebrated its sesquicentennial. Largely industrial in character with emphasis on steel and parts manufacturing, Cleveland is "the best location in the nation." The term is a simple statement of a superlative fact—describing the industrial advantages of the Cleveland area's location in the market center of America.

Cleveland's central location assures a good attendance for conventions and one which is easily accessible to a majority of delegates. Half of the population of the United States is within a 500-mile radius and overnight rail time of the city. Convenient, fast, and modern transportation facilities of all kinds are available in and out of the city.

Cleveland's compact layout is another convention advantage. All major hotels, the shopping district, transportation points, amusements, Lake Erie, and the Public Auditorium are all within a few minutes' walking distance. Any point in the city is easily accessible from the downtown area.

At the hub of the city's business activities is the Public Square, a small clearing of land which was purchased by the Connecticut Land Company in 1795 for $1.76 and which is now a modern business and transportation center valued at more than $20,000,000. Towering over the square is Cleveland's familiar landmark, the 52-story Terminal Tower, with an observation room on the 42nd floor that affords a splendid view of the city. It is the seventh tallest building in the world, the other six being in New York. Other parts of the Terminal unit are the Union Terminal, Higbee's department store, the Cleveland Hotel (which is headquarters for the ASQC convention), several shops, restaurants and cafes.

Building attractions such as this aren't confined to the Public Square, however. Many huge office and civic buildings dot the Cleveland scene and have attracted the attention of the whole nation. The Mall, for example, is one of the most ambitious undertakings ever attempted. This plan of grouping public buildings around a spacious seventeen-acre downtown garden spot represents an investment of more than $40,000,000. The Mall, which overlooks Lake Erie and extends into the heart of the business district, is made up of seven great buildings. America's best equipped convention plant—the $10,000,000 Public Auditorium; the Federal Building; the Public Library; the Board of Education Building; City Hall; Cuyahoga County Court House; and the lakefront Municipal Stadium, seating 83,000, are included in the Mall Development.

Famed throughout the country for its unique facilities and capacity, the auditorium has housed many of the largest meetings and expositions that are annually held in the United States. It is considered to be America's finest and most serviceable municipal auditorium, and it is here where the ASQC 13th Annual Convention and National All-Industry Quality Control & Production Exposition will be held.

The Hall has three theaters, ten halls seating 75 to 500 each, and many committee rooms and offices which make it ideal for an all-around convention operation. The main auditorium seats 12,500; the Music Hall seats 3,000 and can be thrown together with the main hall so that 16,000 can watch the action on the 5,000 square foot stage.

Cleveland also ranks among the nation's outstanding cultural and educational centers. Western Reserve University, comprising various colleges, is one of Ohio's oldest and best collegiate institutions. Case Institute of Technology adjoining the campus of Western Reserve, is among the country's top engineering schools. The two institutions occupy high ground overlooking beautiful Wade Park. Other Cleveland collegiate institutions are John Carroll University and Fenn, Ursuline and Notre Dame colleges.

Gems of the city's cultural treasures are the Cleveland Museum of Art and Severance Hall, both located in University Circle overlooking Wade Park on Cleveland's east side. The art institution is one of the most beautiful museum buildings in America and through its cooperation with the city's schools and colleges has become an essential factor in the educational life of Cleveland.

Severance Hall is the $2,500,000 home of the Cleveland Symphony Orchestra and has done much to carry the story of Cleveland's educational and cultural progress to the rest of the world. Other famous institutions in Cleveland include the Museum of Natural History, the Western Reserve Historical Society Museum, Dunham Tavern, the Public Library, the Health Museum, Brookside Zoo, Nela Park University of Light, and Cleveland Hopkins Airport.

In addition to visits to Cleveland's many noted landmarks, there is a great variety of recreation and entertainment pleasures in store for the city's guests. Outdoor lovers can get their fill in the community's park system, swimming in Lake Erie, golf, tennis, American League baseball, horse racing, boating and numerous summer resorts.

Cleveland's show houses present the cream of the nation's theatrical talent. In Playhouse Square, with its 12,000 seating capacity, theaters not only offer excellent productions, but they also are attractions in themselves.

With Cleveland in an especially fine mood to welcome its guests and with the city's traditionally kind and friendly spirits as a convention host in the offering, visitors attending the ASQC convention are in for a memorable experience.

ASQC Convention Exposition Chart

13TH ANNUAL CONVENTION AND NATIONAL ALL-INDUSTRY QUALITY CONTROL & PRODUCTION EXPOSITION
CLEVELAND PUBLIC AUDITORIUM
MAY 25-27, 1959

SCHEDULE OF EVENTS

General Registration, All Technical Sessions, Exhibits, and Scheduled Daily Luncheons will be held at Cleveland Public Auditorium, a five-minute walk from Hotel Sheraton-Cleveland, the headquarters' hotel.

GENERAL PROGRAM

SUNDAY—MAY 24

6:00-9:00 pm	Cleveland Section Open House: Whitehall Room of Hotel Sheraton-Cleveland. Special registration desk on mezzanine open from 4-9 pm today only.

MONDAY—MAY 25

8:30 am	Registration: Public Auditorium only.
8:30 am-9:00 pm	Exposition hours: Public Auditorium.
9:00 am-12:15 pm	Technical Sessions.
12:30 pm	Luncheon.
2:30 pm	*Plant Visits: Ford Motor Company Foundry; Sohio Research Lab; Aluminum Company of America
2:30 pm-5:15 pm	Technical Sessions.
4:15 pm	Annual Meeting, ASQC: Club Room B, Public Auditorium.
9:00 pm	†Social Evening: Ballroom of Hotel Sheraton-Cleveland.

TUESDAY—MAY 26

8:30 am	Registration: Public Auditorium only.
8:30 am-6:00 pm	Exposition hours: Public Auditorium.
9:00 am-12:15 pm	Technical Sessions.
12:30 pm	Luncheon.
2:30 pm	*Plant Visits: Lewis Research Laboratory of N.A.S.A.S.; Republic Steel Corporation.
2:30 pm-5:15 pm	Technical Sessions.
6:30 pm	Annual Banquet: Ballroom of Hotel Sheraton-Cleveland.

WEDNESDAY—MAY 27

8:30 am	Registration: Public Auditorium only.
8:30 am-5:00 pm	Exposition hours: Public Auditorium.
9:00 am-12:15 pm	Technical Sessions.
12:30 pm	Luncheon.
2:30 pm-4:00 pm	Technical Sessions.

LADIES' PROGRAM

Ladies' Headquarters: Whitehall Room, Mezzanine of Hotel Sheraton-Cleveland. Both advance and current registration here only.

MONDAY—MAY 25

9:00 am	Hospitality Hour: Whitehall Room. Feature: Oddities in Precious Gems—H. W. Beattie & Sons.
12:30 pm	Luncheon and Style Show: The Higbee Company Lounge.
9:00 pm	†Social Evening: Ballroom of Hotel Sheraton-Cleveland.

TUESDAY—MAY 26

8:30 am	Hospitality Hour: Whitehall Room. Feature: Color in Your Life—Mrs. Nora Hollett, Ohio Bell Telephone Company.
9:30 am	Visit to American Greetings Corporation Plant.
2:00 pm	Cleveland Art Museum—May Showing.
6:30 pm	†Annual Banquet: Ballroom of Hotel Sheraton-Cleveland.

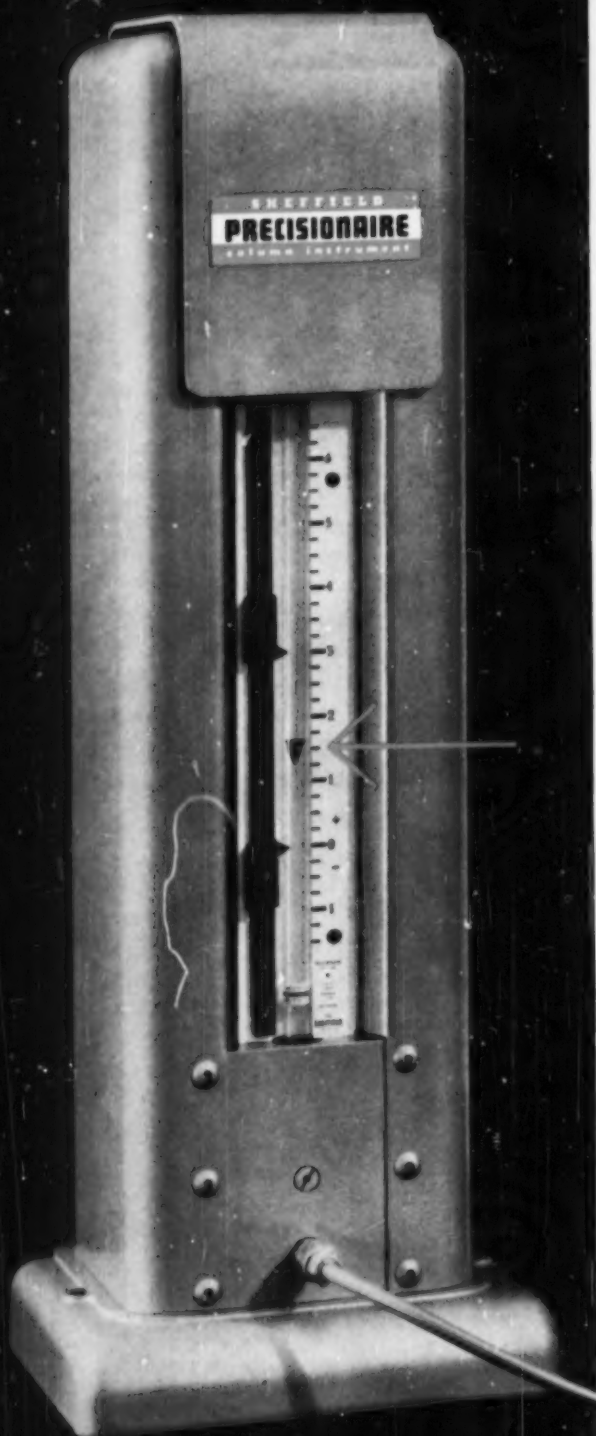
WEDNESDAY—MAY 27

8:30 am	Hospitality Hour: Whitehall Room.
9:15 am	Visit to Hough Bakeries—Catering Plant. Visit to Stouffer's Frozen Foods Plant.

*Special nominal registration fee to help defray the expenses of this activity. Tickets available in general registration area only. Buses leave from Public Auditorium.

†Optional extra cost item—not included in registration fee.

Buses for Ladies' Program events leave from the Hotel Sheraton-Cleveland.



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Practical Aids

ELLIS R. OTT, *Editor*

Rutgers University, 77 Hamilton Street, New Brunswick, N. J.

Nomograph for Binomial and Poisson Significance Tests

ERIC E. JOHNSON

Y-12 Plant, Union Carbide Nuclear Company, Oak Ridge, Tenn.

Simple tests of the significance of the difference between two sample means from normal populations are based on tables of the normal or the Student-t distribution. Analogous tests are frequently required in analyzing observations from binomial or Poisson distributions, for example in making comparisons of fraction defectives or number of defects per unit. The problem of significance testing with respect to these distributions will be considered.

The practice of setting up a test statistic with the observed discrete variables, and referring the statistic to a normal probability scale for a decision on the relevant hypothesis may be adequate in some cases.[1]

A more general method[2] is presented in Bennett and Franklin's *Statistical Analysis in Chemistry and the Chemical Industry*. This method for making significance tests with attribute data does not depend so directly on the normality assumption and hence should be preferred when making these tests. However, evaluation of the t_2-t_1 equations[2] for routine binomial and Poisson significance tests is rather time consuming using desk calculator methods of computation. A more rapid method was developed by designing a nomograph to evaluate the $\sqrt{yz}$ terms in these equations. It will be noted there are four of these terms in each of the following:

Binomial

$$t_2-t_1 = 2\left[\sqrt{\hat{p}\ (n_1-x_1)} - \sqrt{\hat{p}\ (n_2-x_2+1)} - \sqrt{(1-\hat{p})\ (x_1+1)} + \sqrt{(1-\hat{p})\ x_2}\right]$$

where x_1 and x_2 are the number of successes in samples of n_1 and n_2,

$$\hat{p} = \frac{x_1+x_2}{n_1+n_2},\ x_1 < n_1\ \hat{p} \quad \text{and} \quad x_2 > n_2\ \hat{p}$$

Poisson

$$t_2-t_1 = 2\left[\sqrt{\hat{\lambda}n_1} - \sqrt{\hat{\lambda}n_2} - \sqrt{x_1+1} + \sqrt{x_2}\right]$$

where x_1 and x_2 are the observed total counts in n_1 and n_2 observations,

$$\hat{\lambda} = \frac{x_1+x_2}{n_1+n_2},\ x_1 < n_1\ \hat{\lambda} \quad \text{and} \quad x_2 > n_2\ \hat{\lambda}$$

In these expressions $\hat{\lambda}$ is equivalent to u' defined in the ASQC Standard A1-1951.

A simple nomograph for the equation type, $\sqrt{yz}$, consists of three parallel equidistant logarithmic scales. These scales can be constructed quickly on three axes drawn parallel on 3 cycle semi-logarithmic paper. The nomograph (see page 24) illustrates the construction of the appropriate scales for the evaluation of the t_2-t_1 equation. For con-

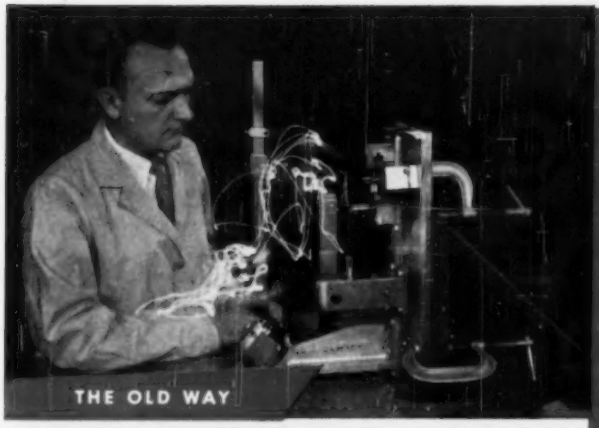
Purdue University Offers Short Courses

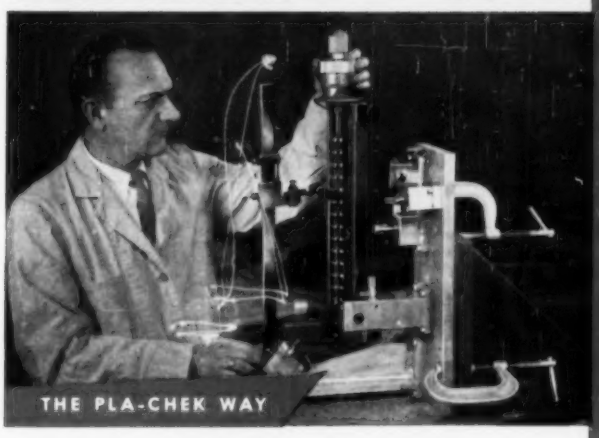
A ten-day short course on the "Designs of Experiments" for statisticians, QC personnel, engineers, and others in industry who are concerned with planning and interpreting the results of industrial experiments will be offered for the first time at Purdue University this summer, June 9-19. Topics included in the short course are: review of analysis of variance, principles of experimental design, variance component analysis, radomized blocks and Latin squares, factorial experiments, split plot designs, confounding in factorial experiments, incomplete block designs, fractional replications, and Box-Wilson response surface techniques for optimality. Prof. Charles R. Hicks, of the Purdue mathematics and statistical staff who is the course director, emphasizes that this advanced course is for persons who have had previous statistical training including work on tests of hypotheses, linear correlation, and at least an introduction to analysis of variance.

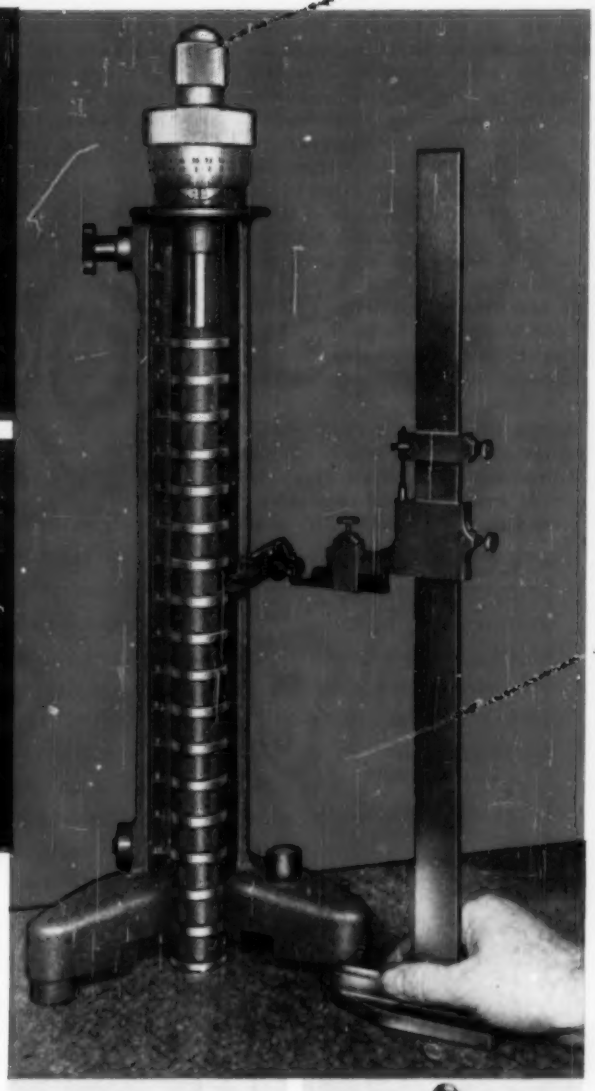
Concurrently with the above course, Professor Irving W. Burr will offer his advanced short course in QC which he has given at Purdue since 1947. It is designed for those who have had the equivalent of one of the intensive courses in SQC given during and after the war, and who want to learn more about the statistical approach to industrial and research problems. Topics to be included are: significance tests and confidence intervals, significance of differences, linear correlation and regression, single sampling for measurements, sequential sampling for measurements, multiple correlation, and analysis of variance.

Further information about these two courses may be obtained by writing to:

Prof. Charles R. Hicks (design of experiments course)
Prof. Irving W. Burr (quality control course)
Engineering Administration Building
Purdue University
Lafayette, Indiana







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venience in computation, the left hand scales on the nomograph are used for evaluating the first two terms in the t_2-t_1 equations, and the right hand scales are used for the last two terms in these equations. A choice[3] between the binomial and Poisson equations is often forced by the type of data. Values of x_1/n_1 and x_2/n_2 greater than 0.05 indicates that the binomial test is appropriate and values of x_1/n_1 and x_2/n_2 equal to or less than 0.05 indicates that the Poisson test should be used.

The following *examples* for the two tests illustrate the use of the nomograph:

Binomial (x_1/n_1 and $x_2/n_2 > 0.05$). Two laboratories performed 145 and 109 analyses of a given type and made 11 and 21 reruns respectively of these analyses because of gross errors. The values to be entered on the left hand scales are as follows: $\hat{p} = 0.126$, $n_1-x_1 = 134$ and $n_2-x_2+1 = 89$. The square roots of the products read from the left hand scale on the central axis are then:

$$\sqrt{\hat{p}\ (n_1-x_1)} = 4.1$$

$$\sqrt{\hat{p}\ (n_2-x_2+1)} = 3.3$$

The values to be aligned on the right hand scales are: $1-\hat{p} = 0.874$, $x_1+1 = 12$ and $x_2 = 21$. Results for the last two terms in the t_2-t_1 equation which are read from the right hand scale on the central axis are:

$$\sqrt{(1-\hat{p})\ (x_1+1)} = 3.2$$

$$\sqrt{(1-\hat{p})\ x_2} = 4.2$$

The t_2-t_1 value is then $2(4.1 - 3.3 - 3.2 + 4.2) = 3.6$. Since this is greater than 2.77, the 5 percent level of significance, and just below the 1 percent level of 3.64 (See Table 10.7, Ref. 2), these data indicate that at the 5 percent level there is a significant difference in the proportion of reruns necessary in the two laboratories.

Poisson (x_1/n_1 and $x_2/n_2 \leq 0.05$). The number of rejects in a particular month's production of 1642 items as determined by 100 percent inspection was 62 items. The following month's rejects was 45 items in 1703 items produced. To test whether the difference in the proportion of rejects is significant, the use of the t_2-t_1 Poisson equation is appropriate. The values for the left hand scales are: $\hat{\lambda} = 0.032$, $n_1 = 1703$ and $n_2 = 1642$. Values for the square roots of the products read from the middle scale are:

$$\sqrt{\hat{\lambda} n_1} = 7.3$$

$$\sqrt{\hat{\lambda} n_2} = 7.2$$

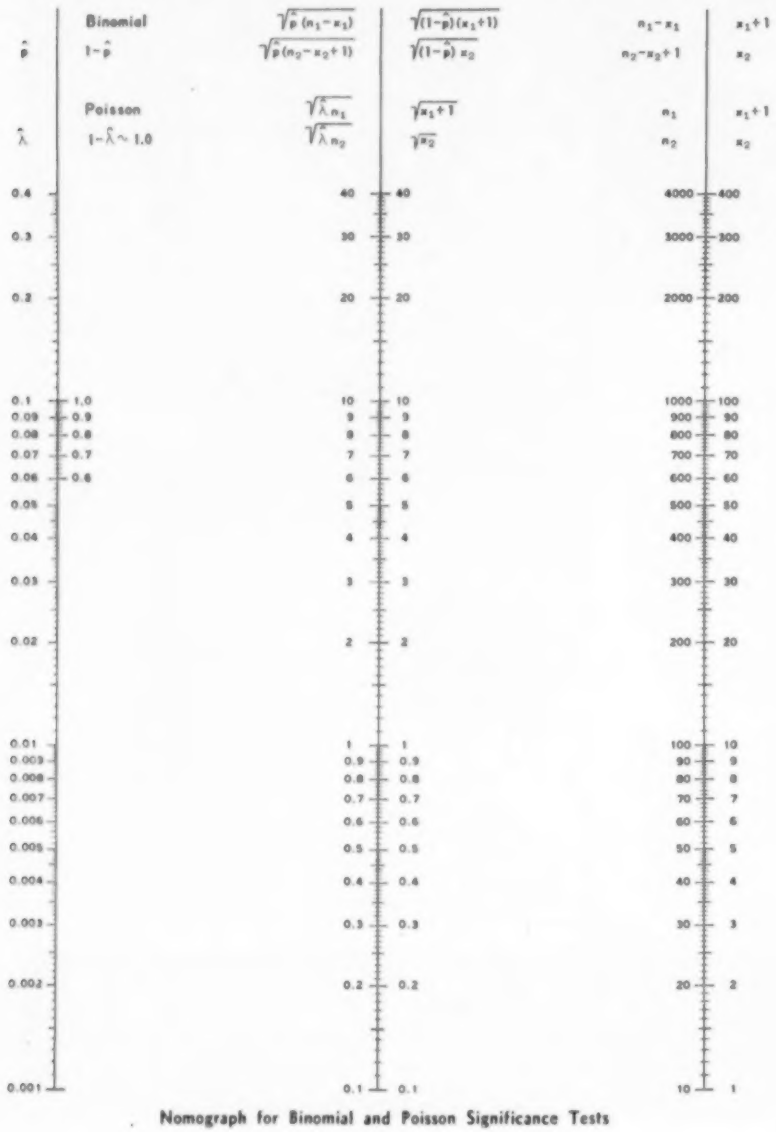
The values for the right hand scales are $1-\hat{\lambda} \sim 1.0$, $x_1+1 = 46$, and $x_2 = 62$. Results for the last two terms in the Poisson equation obtained from the middle scale are:

$$\sqrt{(1-\hat{\lambda})\ (x_1+1)} = 6.7$$

$$\sqrt{(1-\hat{\lambda})\ (x_2)} = 7.8$$

Combining these results, the t_2-t_1 value is $2(7.3 - 7.2 - 6.7 + 7.8) = 2.4$. Since this is below the 5 percent level of significance, 2.77, we accept the hypothesis of equal means of the proportion of rejects at the 5 percent level.

Since the construction of the nomograph consists of uniform logarithmic scales, the accuracy of the nomograph will be approximately the same as the accuracy of a slide rule of a length equal to one of the logarithmic scales.



Nomograph for Binomial and Poisson Significance Tests

References

(1) Dixon, W. J. and Massey, F. J., *Introduction to Statistical Analysis*, Second Edition, McGraw Hill Book Company, Inc., 1957, p. 232

(2) Bennett, C. A., and Franklin, N. L., *Statistical Analysis in Chemistry and the Chemical Industry*, John Wiley and Sons, Inc., 1954, p. 611-612 and Table 10.7 (σ columns) p. 653

(3) Hoel, P. G., *Introduction to Mathematical Statistics*, John Wiley and Sons, Inc., 1954, p. 70

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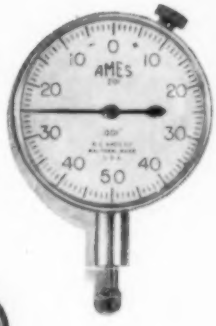

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section briefs

ALBUQUERQUE . . . The Jan. 19 meeting was attended by some 60 members and guests—the largest attendance of any meeting so far this season.

J. H. Hershey, reliability engineer for Bell Telephone Laboratories, gave a most interesting talk on "Predicting reliability numbers." While in Albuquerque, Mr. Hershey visited Sandia Corp.

ALLENTOWN-BETHLEHEM . . . We had a good turnout of members for the Jan. 14 meeting. We were fortunate to have two experienced and interesting speakers from our own section who presented their experiences and application of SQC methods to problems they encountered.

Bud Gillette of Western Electric spoke about "An application of SQC to electron tube manufacture." He briefly outlined how a percent defective chart saved his organization a great deal of money.

Leroy Duncan gave an excellent talk on "Controls in a continuous non-ferrous casting process." He covered the process of making copper with the proper chemical composition. He also discussed the problems encountered in working with large quantities of molten copper.

BALTIMORE . . . The Jan. 20 meeting featured Dr. A. C. Rosander of the Internal Revenue Service who spoke on the subject of "Sampling tax returns." To a captive audience he described the workings of this agency of the Federal government with respect to obtaining statistical data from tax returns submitted by individuals, partnerships, and corporations. Although the returns number in the millions, the data used were, in most cases, sampled and incorporated in an annual report required by the Federal government.

Prior to this meeting, the fifth of seven basic QC training sessions was presented by Miss Marie Delaney of the Social Security Administration.

BATTLE CREEK-KALAMAZOO . . . Dr. W. D. Baten will discuss "Acceptance sampling by variables" at the Apr. 8 meeting which will be held at Michigan State University, East Lansing.

There are 36 students enrolled in the basic QC course currently being conducted by the section. Dr. W. D. Baten and Deland Davis are the course instructors.

BIRMINGHAM . . . The January meeting was held at the new Hotel Stafford in Tuscaloosa. Wyllis G. Stanton, professor of industrial engineering at the University of Alabama, discussed "Reliability problems in QC."

Plans were announced for the section to visit the Stockham Valves and Fittings Co. on Apr. 3. The plant visit will be followed by dinner and a discussion of "QC applications at Stockham" by C. L. Pifer, QC supervisor at Stockham.

CHARLESTON . . . Dr. Gayle W. McElrath, University of Minnesota, entertained as well as informed an appreciative audience on "Why design experiments?" A clear-cut answer, highly appealing, was heard and later transmitted to "non-believers" by even former skeptics! Any program chairman who would like to create a solid interest in SQC should contact Dr. McElrath.

The section devoted a program to QC engineering topics during the last dinner meeting. A significant response to Wyatt Lewis' excellent speech was detected from the audience.

CHATTANOOGA . . . A plant visitation of Combustion Engineer's Chattanooga plant was on the agenda for the January meeting. Members had an opportunity to study QC techniques in action in the manufacture of sewer pipes.

CHICAGO . . . The basic educational meetings, conducted the first and third Thursdays of each month, are well attended averaging over 100. The inspection training program, held every Tuesday through May 19, is averaging about 50.

The general meeting will be held Apr. 15 at the Furniture Club, 666 N. Lake Shore Drive. An interesting subject is planned for 5 pm but the speaker is not definite as yet. At 7:30, Dr. Raymond B. Wakefield, director of research for Gerber Baby Foods, will present "Application of QC in the food processing industry."

CINCINNATI . . . At the January meeting a very interesting and entertaining dinner talk was given by Wm. Dawes, WCPO radio personality, on his experiences in the Broadway theater, movies, radio, and TV. Following Mr. Dawes' talk, certificates were awarded to the graduates of the fall educational series by Merv Bratt and Dick Race.

The section was represented at the Jan. 29 management night seminar which was held at the Hotel Netherland-Hilton.

The 8th annual all-day conference on QC, co-sponsored by the Cincinnati and Hamilton-Middletown sections, was held Jan. 31 at the Hotel Sinton. The speakers were outstanding and a new attendance record was set.

The spring educational series has started. Classes are held at the Cincinnati Industrial Institute Building on Langdon Farm Road and are conducted by Mr. Race and Mr. Flischel.

COLUMBUS . . . Due to flood conditions in Columbus and central Ohio, the Jan. 21 meeting had to be cancelled.

Miss Bonnie B. Small, QC consultant for the Western Electric Co., will be the speaker at the Apr. 15 meeting. Miss Small's subject will be "Practical training for QC." Her talk will include many types of visual aids and demonstration techniques. Her visit to Columbus has been planned to coincide with the completion of the manufacturing facilities of Western Electric in Columbus. Her talk will provide a fitting welcome for Western Electric's active participation in the activities of the section.

CORNING-ELMIRA . . . The section wishes to express its thanks to Harmon Bayer, QC consultant, for his excellent talk on "Performing capability studies" on Jan. 12 at the Hotel Langwell. More than 50 people attended and enjoyed a delicious buffet style roast beef dinner .

Final plans for the section's educational program have been announced. Two courses entitled "Process capability studies in production" and "Reliability studies in life testing" to be conducted by Professors Henry Goode and John Kao of Cornell University will be offered. Both courses will

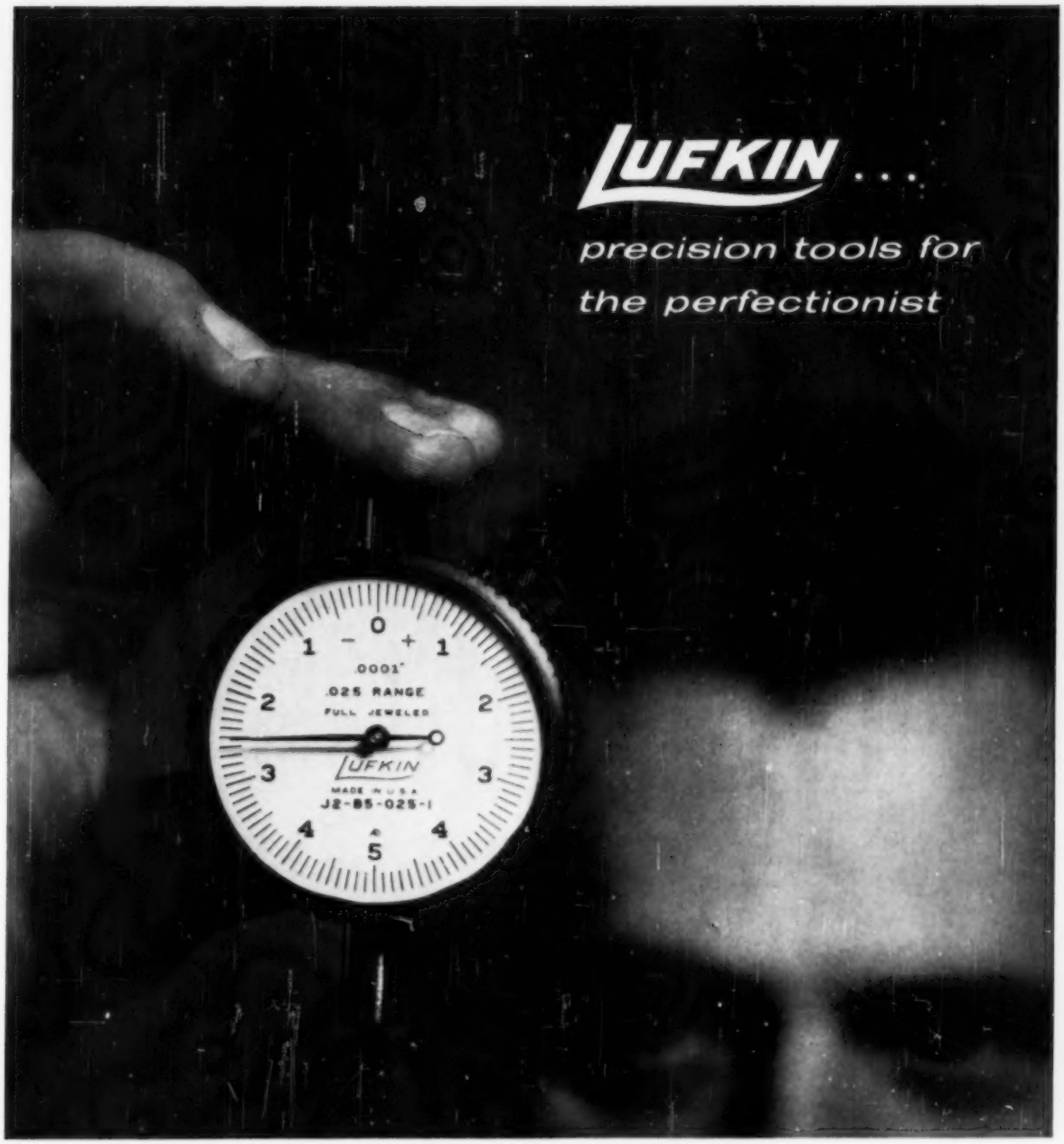
---

Harold F. Dodge Honored at 13th Midwest QC Conference

Prof. Harold F. Dodge, long a leader in developing the science and art of SQC, was the recipient of special honors during the 13th Midwest QC Conference, which was held at Kansas City, Mo.

In the presence of some 275 conference participants assembled in the Grand Ballroom of the Muehlebach Hotel, conference chairman Dr. Frank A. Barta presented Prof. Dodge with a Citation in recognition of his outstanding contributions and dedicated service to the profession. (The photo shows Prof. Dodge on the left accepting the Citation from Dr. Barta.)

Prof. Dodge, who recently retired from his position with the Bell Telephone Laboratories and who is now professor of applied and mathematical statistics at Rutgers University, accepted the Citation and a rousing ovation from the audience and then proceeded to reciprocate. In a two-hour discussion of "Some aspects of acceptance sampling," Prof. Dodge presented an outstanding exposition of sampling theory, concluding with an introduction to his yet-unpublished "Chain sampling plan CSP-3."



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SECTION CALENDAR (MARCH 25—APRIL 31)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Allentown-Bethlehem	Apr. 24	Berkshire Hotel, Reading	6:00 pm	Observations on Interpretations of Measurement Data	John Pringle, Bell Telephone of Canada
Baltimore	Apr. 21	Memorial Stadium	8:15	Response Surface Analysis	Irving Belson, M.S.A. Research Corp.
Battle Creek-Kalamazoo	Apr. 8	Michigan State Univ., East Lansing	8:00	Acceptance Sampling by Variables	Dr. W. D. Baten, Michigan State University
Birmingham	Apr. 3	Stockham Valves & Fittings Co.	3:00	Plant Tour	C. L. Pifer, Stockham Valves & Fittings Co.
Boston	Apr. 16-17	Statler-Hilton Hotel	——	Reliability Symposium	——
Buffalo	Mar. 30	Norton Hall, Univ. of Buffalo	6:30	What Industry Expects of a QC Engineer	Marsh B. Gwynn, Eastman Kodak Co.
	Apr. 27	Western Electric Co., Tonawanda	6:30	Plant Tour	——
Chicago	Apr. 15	Furniture Club	5:00	General Meeting	——
Cincinnati	Apr. 15	Greenhills Country Club, Greenhills	8:00	QC in the Paper Industry	Ted Sooy, Wolverine Carton Co.
Columbus	Apr. 15	Southern Hotel	8:00	Practical Training for QC	Bonnie B. Small, Western Electric Co.
Corning-Elmira	Apr. 14	Baron Steuben Hotel, Corning	7:00	Use of Computers in Industry	Milton E. Terry, Bell Telephone Labs
Dallas-Fort Worth	Apr. 16	Arlington State College, Arlington	8:00	A Quality Assurance Program Using a Demerit Rating System	G. M. Putthoff, Bendix Aviation Corp.
Delaware	Apr. 2	Lord De La Warr Hotel, Wilmington	8:00	Can QC Pay Its Own Way	Robert Shin, Western Electric Co.
Evansville-Owensboro	Apr. 21	Evansville	6:30	The Practical Aspects of Sampling	Keith E. Rose, Essex Wire Corp.
Georgia—Atlanta Group	Apr. 20	Lockheed Aircraft Corp., Marietta	6:15	Plant Tour	Floyd Castle, Lockheed Aircraft Corp.
Greater Detroit	Apr. 16	Veteran's Memorial Bldg.	7:30	Award Paper Presentation	Award Winner
Greater Muskegon	Apr. 9	Spring Lake Country Club	6:30	Plant Problems and QC Methods	Jack Fortenbacher, Centrifugal Foundry
Harrisburg	Apr. 1	Yorktown Hotel, York	6:30	Precision of Measurements	Dr. Frank E. Grubbs, Ballistic Research Lab
Hartford	Apr. 21	Nutmegger House	6:30	Accuracy, Precision of Measurement, Product Variability, and the Analysis of Variance	Dr. Frank E. Grubbs, Ballistic Research Lab
Huntsville	Mar. 26	Decatur	——	Plant Tour	——
	Apr. 16	——	——	SQC in Engineering Research and Development	Paul S. Olmstead, Bell Telephone Laboratories
Indianapolis	Apr. 21	Atherton Center, Butler U.	6:30	Problems in QC Administration and Applications	Panel
Kankakee-Joliet	Apr. 7	Tony's Restaurant, Joliet	7:00	Selling QC to the Factory	Burr Stanton, General Electric Co.
Kansas City, Mo.	Apr. 16	Blue Hills Steak House	6:00	Management of Inspection and QC	O. H. Bishop, Reynolds Metals Co.
Lima	Apr. 21	Superior Coach Corp.	8:00	Gimmicks Help the Quality Program	Allin P. Deacon, Deacon & Associates
Los Angeles	Apr. 14	Rodger Young Auditorium	6:00	Reliability—Its Management	——
Metropolitan	Apr. 15	Hotel Essex House, Newark, N. J.	7:00	Acceptance Sampling Plans—Some Observations	Harold F. Dodge, Rutgers University
Mid-Hudson	Apr. 14	——	7:00	Joint Meeting with ASTE	——
Montreal	Apr. 15	C.I.L. Bldg.	8:15	Statistical Techniques for Adjusting Production Plans to Sales Trends	E. H. Robinson, Johnson and Johnson
Muncie	Apr. 16	Anderson	6:30	Plant Tour—Delco-Remy	——
Northeastern Indiana	Apr. 9	Chamber of Commerce, Ft. Wayne	8:00	Tolerances of Mating Parts	Dr. I. W. Burr, Purdue University
Omaha-Lincoln	Apr. 10	Omaha	7:00	Electron Tube Life Testing	J. A. Davies, General Electric Co.
Parkersburg	Apr. 21	First Federal Savings and Loan Co.	8:00	Business Meeting	——
Pittsburgh	Apr. 28	YWCA, Wood St.	6:30	What Your Husband Does in QC (Wives' Night)	Besse B. Day, U. S. Navy Bureau of Ships
Pittsfield	Apr. 8	Stanley Club	8:00	QC Testing: Product and Packaging	W. F. Bachelder, Testing Machines, Inc.
Portland	Apr. 3-4	Oregon Museum of Science and Industry	9:00 am	7th Pacific Northwest QC Conference	——
Rhode Island	Apr. 16	Providence Engr. Bldg.	8:00 pm	Statistical Methods in Russia	Dr. James H. Davidson, General Electric Co.
Rochester	Apr. 7	Chamber of Commerce	6:15	Digital Computer Applications	J. Stuart Hunter, Princeton University
	Apr. 21	Chamber of Commerce	6:15	Control Charts Without Calculation—Some Modifications and Some Extensions	Prof. Paul C. Clifford, Montclair State Teachers College
St. Charles	Apr. 21	Club Arcada	6:30	The Scope of the Ordnance Corps' Quality Assurance Program	E. L. Meyers, Chicago Ordnance District
St. Louis	Apr. 15	Golden Fried Chicken Loaf Restaurant	6:30	Practical Applications of SQC in Food Processing	Howard L. Stier, National Canners' Association
Salt Lake City	Apr. 10	Union Bldg., Univ. of Utah	7:30	Management Night	Panel Discussion
San Antonio	Apr. 14	Hilton Hotel	7:45	Vendor Quality Rating	G. M. Putthoff, Bendix Aviation Corp.
South Bend-Mishawaka	Apr. 9	Bendix Legion Hall, South Bend	7:30	Forum: Practical QC	Leslye Whitcomb, Dodge Mfg. Co.
	Apr. 16	Bendix Legion Hall, South Bend	7:30	Some Unusual Applications of QC Methods	Carl D. Larson, General Tire & Rubber Co.
Syracuse	Apr. 28	Turn Hall	6:30	Regression Analysis	Prof. Mason E. Wescott, Rutgers University
Toronto	Apr. 8	Univ. of Toronto	8:00	Practical Applications of Probability Paper	Robert Cardno, Canadian GE, Ltd.
	Apr. 22	General Motors, Oshawa	7:30	Plant Tour	——
Tulsa	Apr. 4	Alvin Plaza Hotel	——	First Anniversary All-Day Forum	——
	Apr. 20	Borden's Cafeteria, Sheridan Village	6:15	——	Ralph Humphries, Cessna Aircraft Co.
Univ. of W. Ontario	Apr. 8	Kitchener	8:00	Ladies' Night	——
Youngstown	Apr. 2	Astoria Cafe, Warren	8:00	Measurement Through Quality Costs	H. L. Freeman, General Electric Co.

be held on Wednesday evenings at the Westinghouse Plant, Horseheads, beginning Apr. 8 and continuing for six weeks. The courses will be scheduled so that individuals may attend either or both.

DALLAS-FORT WORTH . . . Some extras were added to the regular monthly meeting on Jan. 15. First, it was a joint meeting with the North Texas section of ASA. Approximately 15 of their members attended. Second, Bryant Craig, president of Texas Electronic Products Corp. of Dallas, gave a very good demonstration and movie on the advantages and applications of "Q-Trol."

Dr. E. F. Moore, Astrodyne, Inc., then brought a very interesting talk on "Some common sense usage of experimental design and analysis." Refreshments were served after a brief question and answer period.

DELAWARE . . . The April dinner meeting will be highlighted by the presence of Robert Shin, Western Electric Co. Mr. Shin will address the group on "Can QC pay its own way?" A good attendance is expected to hear him as many articles and talks have been presented on this subject and all members should be interested in hearing the views of one with such an outstanding QC background.

Because of illness, Dr. R. W. Kennard was unable to speak at the January clinic session as scheduled. Dr. Wm. Thompson, who is a member of the section, substituted for Dr. Kennard. His subject was "What is statistical inference?" The section is most grateful to Dr. Thompson for offering his services on such short notice.

EVANSVILLE-OWENSBORO . . . A very enjoyable evening was had by all at the January dinner meeting held at Gabe's Restaurant. An extremely interesting program was presented by Robert E. Moe and Jack R. Somerville, both of the Owensboro Tube plant of the General Electric Co. The subject of the program was "Tube reliability in military electronics equipment."

Keith E. Ross, QC manager of Essex Wire Corp., will be the speaker at the Apr. 21 meeting to be held in Evansville. Mr. Ross will speak on "The practical aspects of sampling."

GEORGIA—Atlanta Group . . . On Jan. 19 at Georgia Tech Lawrence F. Jones, superintendent of QC, semiconductor department, Westinghouse Electric Corp., gave an instructive talk on "Investigating assignable causes."

A visit to the Lockheed Aircraft Corp. plant at Marietta is scheduled for Apr. 20 at 6:15. Dinner will be served in the plant cafeteria. Floyd Castle, Lockheed, will explain some problems in aircraft assembly.

GREATER DETROIT . . . Continuing in its usual dynamic role in ASQC activities, the section instituted a new program this year aimed at putting its membership in the limelight. For the first time in the history of the section an opportunity was given the entire membership to prepare individual technical papers on a competitive basis. These papers are now being judged by nationally prominent ASQC members. The winner will be afforded the opportunity to present his paper at the dinner meeting to be held Apr. 16.

"Evolutionary operation—its method and application" was explained by T. L. Koehler when he addressed the Dow Quality Society on Jan. 13. Preceding Mr. Koehler's address, the members of the Society met under the leadership of Paul Hass of the Saran Statistical Analysis Department to discuss "Normal Curve tables and their uses." This event was jointly sponsored by the section and the Midland Engineering Society.

The success of the dinner dance held Jan. 31 assures the fact that this social affair will remain an annual event.

GREATER MUSKEGON . . . Thirty-nine members and guests enjoyed an interesting presentation by Carl Hoover on the QC program at Perfect Circle, manufacturers of piston rings. Mr. Hoover presented some very interesting examples as to how properly planned QC experiments payed off. He stated that a great deal of money was being spent to obtain data but its value was not being gained due to lack of applying the technical rudiments of SQC. Their program was based on 4 M's—machine, material, measurement, and man. The talk was preceded by a delicious filet mignon dinner.

Jack Fortenbacher of the Centrifugal Foundry will discuss plant problems and the QC methods used for handling them at the Apr. 9 meeting to be held at the Spring Lake Country Club.

HAMILTON . . . Charles A. Bicking of the Carborundum Co. held the interest of the section with his presentation of "Experimental Design." His important contributions were the practical applications of statistical methods to experimental work. This included information about correctly formulating the experiment, correct choice of method, the

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handling of a number of variables by different methods, and accurate interpretation of results.

The section, in participation with the Cincinnati section, sponsored the 8th annual all-day conference at the Hotel Sinton in Cincinnati on Jan. 31. The conference presented for industry the techniques of SQC. There were sessions for every field and much interest was shown by the participants.

HARRISBURG . . . Dr. Frank E. Grubbs, Ballistic Research Laboratory, Aberdeen Proving Ground, Md., will present "Precision of measurements" at the Apr. 1 dinner meeting to be held at the Yorktown Hotel in York. The moderator for the program will be Albert J. Krause, York Div., Borg-Warner Corp.

HARTFORD . . . Warren R. Purcell, Raytheon Mfg. Co., spoke at the January meeting on the scope of QC. In his talk, he covered the nine areas in which QC assists in the problem of manufacturing products which will yield full customer satisfaction while at the same time minimizing the cost due to process variations and production devices. The discussion period which followed stressed the importance of liaison between design engineering and QC.

Vice chairman Herb France, Jr. then employed Mr. Purcell's charts to determine the areas of interest of the audience as an aid in preparing the program for the coming year.

HUNTSVILLE . . . Edward Balog, U. S. Steel Corp., gave an interesting and informative talk on "The nature of QC" at the January dinner meeting.

The section will arrange to have a plant tour of one of the companies in the area as the Mar. 26 meeting. The time and place will be announced later.

On Apr. 16, Paul S. Olmstead of the Bell Telephone Laboratories will present "SQC in engineering research and development."

INDIANAPOLIS . . . The Jan. 20 meeting was well attended. Henry Jacobson gave a most interesting talk on "QC as a profession" outlining the duties, responsibilities, and goals of QC personnel. January 20 was also proclaimed as "QC Day" in Indianapolis by Mayor Charles H. Boswell. Section president John W. Waldner received the proclamation from

Mayor Boswell. (In the photo, left to right: H. Melvin Handerson, section vice president; Henry J. Jacobson, speaker of the evening; Mr. Waldner; Mayor Boswell; Thomas E. Turner, Society Director; George Blackburn, section publicity and public relations chairman.)

The 14th Midwest QC Conference will be held at French Lick during 1959. Our team is working on this conference and now has 21 top drawer speakers for all the technical sessions. In addition, they are awaiting word from a very distinguished, nationally known man for the program.

KANKAKEE-JOLIET . . . L. R. Stickler, R. R. Donnelly Company, spoke on the "Use of QC in the printing industry" at a recent meeting.

On Apr. 7 Burr Stanton, General Electric Co., will present "Selling QC to the factory." The meeting will be at Tony's Restaurant, Joliet, at 7 pm.

KANSAS CITY . . . Some 40 couples enjoyed the winter social evening on Jan. 17. Held in the Johnson County Community Center, the social featured juke-box dancing, games, singing, and fun-type activities. High spot of the evening was a midnight spaghetti and meat-ball dinner superintended by chief chef Bill Atwater. A great time was had by all attending and it's even rumored that there was no deficit for a change!

LIMA . . . The Jan. 20 meeting was held at the Superior Tube Co. The speaker, J. C. Sorenson of Aeronica Mfg. Co., talked on the subject of "Process control." Over 50 mem-

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bers and guests were in attendance in spite of hazardous icy road conditions. One of the many interesting facets of Mr. Sorenson's talk dealt with how men for key QC jobs are chosen and how their training is consolidated at each step in their career.

A chicken-in-the-basket dinner was served and the meeting was followed by a plant tour. Clair Zimmerman, Superior's chief inspector, conducted the party through the plant where the group learned a great deal about the finest quality tubing used extensively in the electronics industry and for surgical purposes.

LOS ANGELES . . . The section will hold a joint meeting with the San Bernardino section on Apr. 14. The subject of the meeting will be "Reliability—its management."

MEMPHIS . . . The Jan. 15 meeting featured ASA film strips on "Operation research." These films were shown through the courtesy of the Buckeye Cellulose Corp. represented at the meeting by Glenn Olree.

METROPOLITAN . . . The annual dinner-business meeting was held on Jan. 15 and officers were elected for the coming year. Those elected were: chairman—Miss Mary Torrey, first vice chairman—William Frey, second vice chairman—Al Sternberg, treasurer—Sid Lewis, and secretary—Lawrence Dorsky. C. E. Fisher, Society President, outlined the objectives and goals of the Society. Simon Collier followed Mr. Fisher on the program. Mr. Collier emphasized the vital role played by "People as it pertains to QC" apart from the statistical considerations.

On Apr. 15 the monthly meeting will be held at the Hotel Essex House in Newark at 8 pm. The subject will be "Acceptance sampling plans—some observations" and the speaker will be one of the most qualified men in the country —Harold F. Dodge of Rutgers University. The meeting will be preceded by another of the popular QC clinics at 7 pm.

MONTREAL . . . The January meeting featured a most interesting demonstration of the use of probability paper in a QC department by Robert Cardno of the Canadian General Electric Co.

Because of the large number of applications for the basic SQC course held in the fall, the section has started a second series of lectures with a full enrollment. R. Vance Ward is again giving the lectures.

The section looks forward to the Apr. 15 meeting when E. H. Robinson of Johnson and Johnson will present "Statistical techniques for adjusting production plans to sales trends."

MUNCIE . . . Our January meeting was outstanding! D. G. Browne moderated for a trio of our own section members. F. E. Jolliffe, G. Rude, and P. J. Infante each discussed a phase of QC in his own plant. It was one of the most enjoyable and enlightening meetings of the year.

Thursday night, Apr. 16, will mark our second plant tour of the season. Delco-Remy's Anderson installation is the target. Dinner will be served at the plant prior to the tour. Notice of time and transportation arrangements will be locally published in ample time to allow all those interested to make convenient plans to join us.

NORTHEASTERN INDIANA . . . Max Comerford and Harold Brunner, General Electric Co., teamed up to present a good discussion on "Use of $\bar{X}$ and R charts." The meeting was well attended.

Prior to the regular meeting, a one-hour training session feature was presented by Gene Warwick. Mr. Warwick, General Electric Co., presented "Statistical inference in classical and factorial designs."

OMAHA-LINCOLN . . . The January meeting was held at Marchio's in Omaha. Sam L. Grasso gave a talk on QC at Inland Automatic and a report on his activities as Society Director.

PARKERSBURG . . . Our regular meeting was held on Jan. 20. A panel consisting of Robert Shattuck, L. B. Haskins, A. G. Custer, and P. R. Gibson discussed "Management and QC." Jim McMasters acted as moderator for the lively discussion. Several points of mutual interest were discussed. Forty-eight members and guests, representing nine companies in the area, attended the panel discussion.

Educational chairman Larry Parker reports that the basic and advanced QC courses taught by J. D. Byan, W. A. Bower, P. W. Huffman, and E. H. Ten Eyck are progressing very nicely.

PENSACOLA-MOBILE . . . Twenty-six members and 11 guests attended the Jan. 20 meeting. L. K. Reitz, Eastman Kodak Co., gave a most interesting and educational presentation on the fundamental application of SQC.

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President A.S.Q.C.

E. F. Dertinger
Raytheon Mfg. Co.

Warren Purcell
Raytheon Mfg. Co.

Prof. Benj. Epstein
Wayne/Stanford Univ.

J. J. Riordan
Office-Ass't. Sec. of Defense

W. H. Lewis
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PITTSBURGH . . . The January meeting was held at the Wood Street YWCA. After a fine dinner, Dr. W. D. Fitzpatrick of the Harbison-Walker Refractories Co. spoke to the section. His topic was "QC in the manufacture of refractories." Dr. Fitzpatrick covered the entire field from the mining of clay to the testing of brick for composition and dimensional properties.

The section was host to the Metals Technical Committee during their two-day January session. The meeting was in the form of a problem seminar discussing the use of SQC in the metals industry. The meeting was quite informal and those present enjoyed it tremendously.

The Apr. 28 meeting will be "wives' night" at which time Miss Besse B. Day of the U. S. Navy Bureau of Ships will speak on "What your husband does in QC."

PITTSFIELD . . . Over 50 members and their ladies attended the annual Ladies' Night. The program featured a tour of the Byron Weston Co. paper mill from stock preparation throughout the manufacturing process to final packaging and shipping. After the tour, dinner was served at the Stanley Club and a color movie describing the cigarette paper making process at the Peter J. Schweitzer Division was shown.

Our Apr. 8 meeting will bring W. F. Bachelder, Testing Machines, Inc., to the area. Mr. Bachelder will speak on "QC testing: product and package." He will review the status of standard physical tests on products and containers as well as discuss new developments in this field.

PORTLAND . . . Well, Apr. 3-4 is it—we will see if the executive committee can bask in the glory of a successful conference. Here's the opportunity for all section members to get on the band wagon and support this conference.

This conference will introduce many new departures from the norm. For instance, the conference brochure was designed to be eye-appealing and useful as well as informative, but different than any previous brochure.

The education committee has prepared a terrific 2-day training course loaded with gimmicks that will provide windows to understanding. The strongest opposition will leave the conference as one of the strongest supporters of SQC methods. Each member should bring at least two "die hards" or "doubters" from his firm and place them in the hands of Hank Blood, Ray Vanderzanden, Dr. Worthington, and Don Hancock.

RACINE . . . At the last meeting, the Engis Equipment Co. gave a presentation entitled "Optical tooling for general industry."

RHODE ISLAND . . . At our January meeting, Dorian Shainin of Rath & Strong gave an excellent presentation entitled "Cost-shooting; now ready for managers to use." Mr. Shainin described in a clear and concise manner, as well as in simple and easily understood terms, the various statistical aids which can be taught to manufacturing, purchasing, inspection, and engineering to help reduce avoidable costs drastically.

ROCHESTER . . . On Jan. 6 the gaging and measurement sub-group heard an interesting talk by Russell Penney, New York Air Brake Co. Mr. Penney discussed "Production measurement of precision tolerances."

January 15 saw a very large section turn-out to hear George A. Henderson, Redstone Arsenal. He talked about the "Relationship of reliability and QC in the Army Ordnance Missile Command."

J. Stuart Hunter of Princeton University will address the technical sub-group on Apr. 7. His subject will be "Digital computer applications."

On Apr. 21 the regular section meeting will have as guest speaker Prof. Paul C. Clifford of Montelair State Teachers College. His topic will be "Control charts without calculation—some modifications and some extensions." It will also be election of officers night.

Your reporter goofed in the January issue. Apologies go to Robert Morris, J. Stuart Hunter, and the membership.

ST. CHARLES . . . Henry J. Becker, American Steel & Wire Division of U. S. Steel Corp., gave a very interesting talk

LESTER W. BALSER

The Rhode Island section was deeply saddened by the sudden death of its chairman, Lester W. Balser, on Jan. 19. Mr. Balser, a senior member, had been active in section activities for many years, having been treasurer since 1950 to his election as chairman for this year. He was foreman of inspection and testing of the wiring device inspection division of General Electric in Providence.

at the Jan. 20 meeting on the subject "Statistical QC applications in metallurgy." His talk was preceded by a pre-dinner seminar on "Process controls-variables" conducted by Prof. H. R. Swenson.

The section is sponsoring a course in "Professional QC management and engineering." The course sessions are held on Saturdays from 8 am to 12 noon at St. Charles High School. Instructors are W. R. Fischer and G. S. Evensen.

ST. LOUIS . . . Although adverse weather conditions limited attendance at the Jan. 21 anniversary meeting, all those who did attend enjoyed the speaker, C. E. Fisher, Society President. Mr. Fisher brought with him many interesting ideas concerning the professional development of engineers in QC.

On Apr. 15, the section will hold a joint meeting with IFE at the Golden Fried Chicken Loaf Restaurant (5867 Delmar). Howard L. Stier will present "Practical applications of SQC in food processing."

SALT LAKE CITY . . . The first meeting of the new year was held Jan. 16 at the University of Utah with a large and enthusiastic audience. The educational part was presented by Dr. H. E. Flanders. It consisted of a concise, erudite review of "Precision constants," illustrated with representative samples.

The guest speaker, P. H. Dnistran, project engineer at Marquardt Aircraft Co., was well qualified to discuss the subject of "QC testing as related to Ramjet engine production." He charted the part played by QC in the design, construction, and test of Ramjet engines, and illustrated his talk with two colored-movies. Both talks were well received.

SAN ANTONIO . . Dr. E. F. Moore, Astrodyne, Inc., addressed the section on Jan. 10. Dr. Moore's paper was titled, "Some common-sense usage of experimental design and analysis" and was well received.

E. W. Doiron, section secretary and general chairman of our 1960 one-day symposium, announced that Feb. 20, 1960 has been designated as the date for our first symposium. Additional information relative to this major event will be published soon.

Our educational program, originally scheduled for Feb. 1, has been temporarily postponed two months. This was necessary in order that the program could be co-sponsored by the section and local educational institutions.

SAN DIEGO . . . The highly successful maiden flight of the Convair 880 on Jan. 27 was a source of quiet satisfaction to the section.

Sharing the limelight with Convair employees, who swell the ranks of the section and serve on the executive and other committees, are members from other local firms who furnished components and services to the new jet airliner.

The smooth performance of the 880 is a tribute to ceaseless efforts for control of quality and we of San Diego rightfully claim a share of the credit.

SAN FRANCISCO BAY AREA . . . Seventy-four members and guests were fortunate and indeed honored in hearing Dr. William R. Pabst, Bureau of Ordnance, U. S. Navy, in his address at the January dinner meeting. Dr. Pabst has just completed a one year United Nations' assignment as QC advisor to the government of India. He delayed his return to Washington, D. C. from India to favor the Hawaii subsection and our section with a digest of this most interesting assignment.

The executive committee announces the following action: unanimous nomination and endorsement of Dr. Albert A. Bowker from our section for consideration as 1958 Shewhart Medalist in honor of his outstanding contributions and leadership in the field of modern QC; nomination of Dr. Gerald J. Leiberman for Society Director; nomination of Carl Farden, Hawaii sub-section chairman, as chairman of the Mid-Pacific QC Conference to be held in Honolulu; nomination of Walter Hurd as District 17 representative; affiliation with the San Francisco Engineering Council; a second scholarship grant of $750 was authorized for a graduate student in QC at Stanford for 1959-60.

SOUTH BEND-MISHAWAKA . . . The Apr. 16 meeting will be addressed by Carl D. Larson, General Tire & Rubber Co. Mr. Larson will describe the use of SQC methods in applications other than quality.

SOUTHERN CONNECTICUT . . . A tour through the facilities of the Burndy Corp. and the renowned Burndy Library in addition to a speech by Bern Dibner entitled "Science and the future" were the features of the recent monthly section meeting.

The Burndy Library (which holds over 10,000 books, pamphlets, and exhibits concerned with the origin and

St. Petersburg-Tampa Presented Section Charter

January 12 was an all important date for members of the St. Petersburg-Tampa section. At a dinner meeting at the Desert Ranch in St. Petersburg Beach the section charter presentation was made by Society Director Robert H. Mayes. Col. J. C. Bailey, USAF, was guest speaker and presented General Caldera's "The flight safety story." The total attendance at the meeting was 90.

Officers of the new section are: chairman—R. P. Caruso, Electronic Communications, Inc.; vice chairman—Calvin C. Newtown, General Electric Co., treasurer—Wm. R. Royall, General Electric Co.; secretary—G. R. Stone, Electronic Communications, Inc.; arrangement committee chairman—Henry Nobel.

Society Director Robert H. Mayes presented the section charter to St. Petersburg-Tampa section chairman R. P. Caruso at a recent meeting. Shown, left to right, are: Mr. Mayes, Henry Nobel, R. P. Caruso (accepting the charter), Wm. R. Royall, and G. R. Stone.

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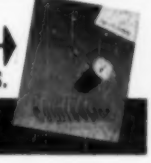

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development of science) was of special interest to those members who represent leading manufacturers, research, and development firms of the Stamford-Norwalk-Bridgeport area.

Mr. Dibner is president of the Burndy Corp. and founder of the Burndy Library.

SYRACUSE . . . At the request of the Industrial Management Club, four Society members—William W. Sorn, Robert M. Hofstead, Richard Holmes, and George Armour—took part in an orientation program for supervisors presented by the club. Each of the men gave a presentation on "What QC can do for industry" at one of the four weekly sessions.

TENNESSEE . . . A very warm welcome to John E. Rose of Johnson City and Gustave W. Hakanson of Kingsport, new members of the section.

The second general meeting of the group which is now the Northeast Tennessee section was held Jan. 9 at Kingsport. James Mitchell, Tennessee Eastman Corp., delivered an informative and interesting address on "Control of the accuracy and precision of industrial test analyses."

J. Pat Reavis, Union Carbide Nuclear Co., was guest speaker at the January meeting of the Statistics Club at the University of Tennessee. His topic was "An application of regression analysis." A lively discussion period followed the talk.

TUCSON . . . Ralph Coltrin, Southern Pacific Co., told members of the section how they could make a million dollars by coming up with solutions to some of the problems faced by the railroads. Among these are loss of passenger traffic, overcoming slippage by a more modern method than the old sand box still carried on even the newest diesels, and solution of labor-management differences.

The section has received numerous inquiries from this and other countries concerning the "Practical SQC" training program co-sponsored by the section and the Hughes Air-

ASQC Honors

Recent Elections to Fellow

CHARLES R. HICKS
Indianapolis section

Mr. Hicks took all of his educational work at Syracuse University receiving an A.B. in 1942, M.S. in 1944, and his Ph.D. in 1953.

He is a member of the editorial board of *Industrial Quality Control* and winner of the 1957 Brumbaugh Award.

He has written several articles on statistics and quality control, and has been guest speaker at numerous Society meetings.

Mr. Hicks has been an instructor at many of the courses held at several of the country's outstanding colleges and universities.

His present position is that of associate professor of mathematics and statistics and research associate, Statistical and Computing Laboratory, Purdue University. In addition, he serves as quality control consultant for several large national organizations.

Mr. Hicks is a member of the American Statistical Association, Institute of Mathematical Statistics, American Association of University Professors, and Pi Mu Epsilon.

JULIUS MEHALEK
Philadelphia section

Mr. Mehalek attended Temple University, University of Pennsylvania, and Pennsylvania State University.

He has held several executive positions with the Philadelphia section; is a member of the Section Development Committee of ASQC; and was publicity chairman for the 7th Annual Convention of ASQC.

Mr. Mehalek has written several articles on statistical quality control and its application to automotive stampings and job shops.

He is a recipient of the Army's certificate of commendation. Presently, he is with The Budd Company.

Mr. Mehalek is a past president and honorary life member of the Lower Bucks County Industrial Management Club, a member of the American Ordnance Association, and a reserve officer in the U. S. Army Ordnance Corps.

W. C. VISSING
Indianapolis section

Mr. Vissing is a graduate of Michigan State College and did graduate work in statistics at Virginia Polytechnical Institute during 1958.

He has held numerous positions with the Indianapolis section and was a Director of the Society in 1957-58.

Mr. Vissing has authored numerous technical papers and contributed a section on statistical quality control to *Remington's Practice of Pharmacy, 1956*.

Since 1952, he has been in inspection and control at Eli Lilly and Company. At present, he is Department Head of the Pharmaceutical Inspection Control Department.

MORRIS HAMBURG
Philadelphia section

Mr. Hamburg is associate professor of statistics, University of Pennsylvania.

OUR EVER-GROWING FAMILY

With the addition of Northeast Tennessee the number of sections in the Society is now 110. The Society is proud to extend a most cordial welcome to the new section.

110—Northeast Tennessee (Dist. 15)

Chairman: Hubert M. Hill
Tennessee Eastman Co.
Kingsport, Tenn.

Vice Chairman: Carl L. Wilson
Tennessee Eastman Co.
Kingsport, Tenn.

Secretary: Joseph T. Johnston
Raytheon Mfg. Co.
Bristol, Tenn.

Treasurer: Myles E. Duellman
S. E. Massengill Corp.
Bristol, Tenn.

craft Co. as described in the December 1958 issue of INDUSTRIAL QUALITY CONTROL. Hughes personnel who have completed this course, now in its fourth series, number more than 300 according to Fred Ennerson, originator and developer of this program.

TORONTO . . . Our speaker at the Jan. 27 meeting presented an excellent discourse dealing with the elimination of short-run production problems by statistical techniques. Mr. Albert's talk was well received and a lively discussion followed.

It was unfortunate that Simon Collier of the Johns Manville Corp. was unable to attend our dinner meeting as guest speaker. P. B. Proctor, also of that organization, consented to appear in his stead and presented the scheduled talk on "QC as related to management and employee." This proved most interesting and promoted considerable discussion.

TULSA . . . Our first QC course was completed on Jan. 26 with 36 of the 56 enrolling for the course completing the instruction. Our thanks go to Prof. Ashworth of Oklahoma State University for lecturing the course. He had quite a drive to make every Monday evening but he didn't miss a class.

The arrangements have been completed for our first anniversary all-day forum to be held on Apr. 4 at the Alvin Plaza Hotel. It promises to be a fine affair with Society President C. E. Fisher finishing the evening as our banquet speaker. The 33 founding members of our section will be honored. All Society members are invited to attend and help us celebrate our first year as a section.

UNIVERSITY OF WESTERN ONTARIO . . . A very successful and enjoyable meeting was held Jan. 14. Case histories, which had been previously prepared, were distributed to the members. A panel was then chosen from the membership to discuss the cases before the group. Keen interest was shown by the members who joined in on the discussion. Refreshments were served after the meeting.

UTICA . . . The Syracuse and Utica sections held a joint one-day clinic at the Hotel Hamilton in Utica. The theme for the clinic was "Quality controls your future."

YOUNGSTOWN . . . Ralph Riefenstahl of Ohio Bell Telephone Co. presented one of the most interesting lecture-demonstrations the section has heard this season. Using a lighted map the speaker demonstrated how automatic electronic devices bypass busy lines to place a long distance call in a fraction of a minute. The telephone system is similar to an electronic computer—in fact, it's the largest. Mr. Riefenstahl described a number of telephone modifications which will be available to the subscriber in the foreseeable future.

On Thursday, Apr. 2, H. L. Freeman from the QC engineering services of General Electric Co. will address the section on "Measurement through quality costs."

SIGNIFICANT DIFFERENCES

. . . Allentown-Bethlehem—Dave Roberts transferred from the inspection department at Mack Truck and is now a QC engineer in the same division.

. . . Baltimore—Hardy M. Cook of the Western Electric Corp. was recently promoted to supervisor of the newly established SQC department.

. . . Boston—Recent position changes are noted for the following members: Cleon L. Lawrence, general foreman, test and inspection, Raytheon Mfg. Co.; Robert C. Lincoln, industrial engineer, Arthur D. Little & Co.; Robert J. Lockhart, senior QC engineer, National Co.; James G. Loder, director of planning, Raytheon Mfg. Co.; Benjamin W. Marguglio, production engineer, Raytheon Mfg. Co.

. . . Corning-Elmira—The section regrets to announce that Floyd Allen had to resign his position as treasurer of the section due to his acceptance of a position with the American Thermostat Corp., South Cairo, N. Y. As a result, Jim Ettorre of the Hilliard Corp. has been appointed as section treasurer for the remainder of the year.

. . . Dallas-Fort Worth—Several courses are presently being conducted by the section. All have a good enrollment and certificates will be given for completion of each section.

. . . Delaware—Congratulations to two members on their recent promotions. Bill Starcher has been made QC supervisor of International Latex Corporation's Southern multi-plant operations, including Puerto Rico.

Francis Holden moves up from QC specialist to QC supervisor at Dover. Bill will be leaving the section as a result of his transfer.

. . . Greater Muskegon—Twenty-four persons were enrolled in a QC training course sponsored by the section. Instructors for the six-meeting course were Glenn Bailey of American Coil Spring Co. and William A. Poe of John Wood Co.

. . . Harrisburg—Theodore Lamparter has assumed responsibilities in QC with Precision Time Corp., Strasburg, Pa.

. . . Hartford—MacChesney Desmond has been appointed field representative for the Nuclear Fuel Operation, Olin Mathieson Chemical Corp.

Harcourt F. Schutz has been named manufacturing manager of the main plant of Fafnir Bearing Co.

Howard L. Parsons has been named superintendent of the inspection division of Fafnir Bearing Co.

Stanley F. Straska has been appointed as QC manager of the Royal McBee Corp. portable typewriter plant which is under construction in Springfield, Mo.

. . . Indianapolis—George McDermott of Delco-Remy is serving his second session as senator of the Indiana State Legislature. Mr. McDermott is a Fellow of the Society.

. . . Lima—Dick Peggs was recently promoted to QC foreman at Ford Motor Co., Lima Engine Division.

. . . Los Angeles—Paul E. Bruce has accepted a position in the advanced engineering department of Autonetics, a Division of North American Aviation, Inc.

. . . Pittsburgh—Irving Belson has left Callary Chemical Co. to take a position as QC engineer at the Westinghouse Electric Corp. Blairsville plant.

Charles M. Fairchild has joined the staff of Pittsburgh Coke and Chemical Co. as an instrument chemist.

Wm. J. McChesney, Jr. received an appointment as a supervising metallurgist in the QC department of the Leechburg Works of Allegheny Ludlum Steel Corp.

clinics, conferences, and courses

MARCH

. . . **26**—15th Annual Clinic, University of Rochester, Rochester, N. Y., sponsored by the Rochester section of ASQC.

APRIL

. . . **3-4**—7th Pacific Northwest Conference for QC, Portland, Ore., sponsored by the Portland section of ASQC.

. . . **4**—All-Day Forum, Alvin Plaza Hotel, Tulsa, Okla., sponsored by the Tulsa section of ASQC.

. . . **5-10**—1959 Nuclear Congress, Public Auditorium, Cleveland, Ohio, contact Engineers Joint Council, 29 West 39th St., New York 18, N. Y.

. . . **16-17**—Reliability Symposium, Hotel Statler-Hilton, Boston, Mass., sponsored by the Boston section of ASQC.

. . . **18-22**—ASTE Annual Meeting, Schroeder Hotel, Milwaukee, Wis., sponsored by ASTE, contact Harry E. Conrad, ASTE, 10700 Puritan Ave. Detroit 38, Mich.

MAY

. . . **11-13**—Joint Automation Conference, Pike Congress Hotel, Chicago, Ill., sponsored by ASME, AIEE, IRE, contact F. D. Snyder, c/o Westinghouse Electric Corp., 40 Wall St., New York 5 N. Y.

. . . **14-23**—International Petroleum Exposition, Tulsa, Okla.

. . . ***25-27—13th Annual Convention and National All-Industry Quality Control & Production Exposition, Public Auditorium, Cleveland, Ohio, sponsored by ASQC.***

JUNE

. . . **8-July 17**—Southern Regional Graduate Summer Session in Statistics, North Carolina State College, Raleigh, N. C., contact F. E. McVay, Dept. of Experimental Statistics, North Carolina State College, Raleigh, N. C.

. . . **9-19**—Design of Experiments Short Course, Purdue University, Lafayette, Ind., contact Prof. Charles R. Hicks, Purdue University, Lafayette, Ind.

. . . **9-19**—Advanced QC Short Course, Purdue University, Lafayette, Ind., contact Prof. Irving W. Burr, Purdue University, Lafayette, Ind.

. . . **16-19**—Industrial Engineering Seminars, Cornell University, Ithaca, N. Y., contact Andrew Schultz Jr., Dept. of Industrial and Engineering Administration, Upson Hall, Cornell University, Ithaca, N. Y.

. . . **22-26**—Symposium on Education in Materials, (ASTM Annual Meeting), Atlantic City, N. J., sponsored by ASTM and ASEE, contact ASTM, 1916 Race St., Philadelphia 3, Pa.

What's New?

ROY A. WYLIE, *Editor*
Ampex Corporation

P-1-7—The LCM 100, a new type of high frequency vibration exciter that features a unique horizontal, air supported shake table, is now available. Although primarily designed for the production testing of components and small subassemblies, full consideration has been given to the requirements of the product design engineer. A wide frequency range (5 to 15,000 CPS) and high output force (up to 100G) will give the LCM 100 broad applications in many fields. The horizontal shake table is push-pull driven from each end and is supported by air bearings. This suspension eliminates "cross talk," a major problem with conventional tables, and does away with troublesome springs and flexures. "Heavy" specimens present no problem, as weight of the table and specimen is supported by air pressure normal to the axis of excitation. The new suspension and push-pull drive provide a flat force output with little phase shift over the entire audio spectrum which results in an efficiency (watts per force-pound) five to ten times higher than other wide band systems. The electrical efficiency of the shaker table is very high (2 watts per force-pound as compared to 10 or more watts per force-pound needed by conventional systems). This enables efficient use of standard audio amplifiers which permits a substantial cost reduction over other vibration exciters using special high power limited frequency amplifiers. Permanent magnets are used in the LCM 100 magnetic circuit to eliminate the need for separate field excitation and associated rectifying equipment. The impedance of the drive coils is designed to match the power amplifier over the entire audio range. The LCM 100 is suitable for use with all forms of excitation including discrete frequency, random noise, white noise, or complex wave forms.

★ ★ ★

P-1-8—A new melting point apparatus designed and manufactured in Switzerland has proved to be eminently successful in carrying out accurate, reproducible determinations in a minimum of time. Heating is rapid to within 5 or 10 degrees of the melting point. Further temperature increases can then be reduced to 1 or 2 degrees per minute. The determination of melting point is one of the most widely used methods of organic chemical research and is used in industry for the characterization of new substances, the identification of compounds, and the purity control of products. The new apparatus saves considerable time between tests because of the small mass of heating fluid used plus its low specific gravity allows rapid cooling. Without compressed air, cooling takes 10 minutes from 300 to 100°C., and 8 minutes more to 60°C. With compressed air, the corresponding times are 4 minutes and 1½ minutes. Stirring of the fluid continues after heat and lights are switched off to help lower the temperature rapidly for the next use. A magnifying lens in a holder, affords convenient observation of the measuring zone with both eyes. Two small lamps throw bright light from both sides onto the test substance. An anti-glare device fitted on the holder reduces eye fatigue. Three standard 3 in. long capillary melting point tubes can be inserted in the small U-shaped "Pyrex" brand glass vessel. It requires only 40 ml of the silicone oil heating medium and the immersion heating coil weighs only 0.5 grams. Therefore, temperature response to heating voltage is practically instantaneous. The stirrer assures homogeneous temperature in the measuring zone. A bearing plate sup-

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TEXAS INSTRUMENTS—28 year old electronics and geophysics company, attributes much of its 20-fold growth in the last 10 years to the recognition of individual achievement. Our planned expansion has created positions with advancement potential for experienced Quality Control Engineers to assume greater responsibility.

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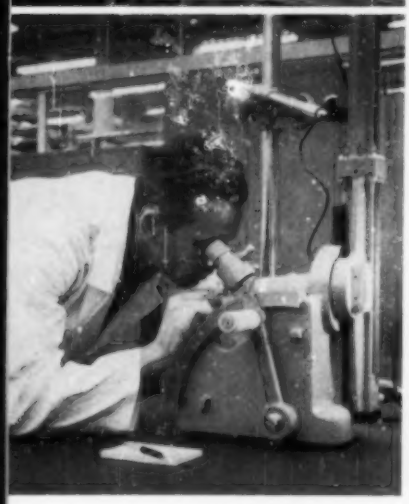
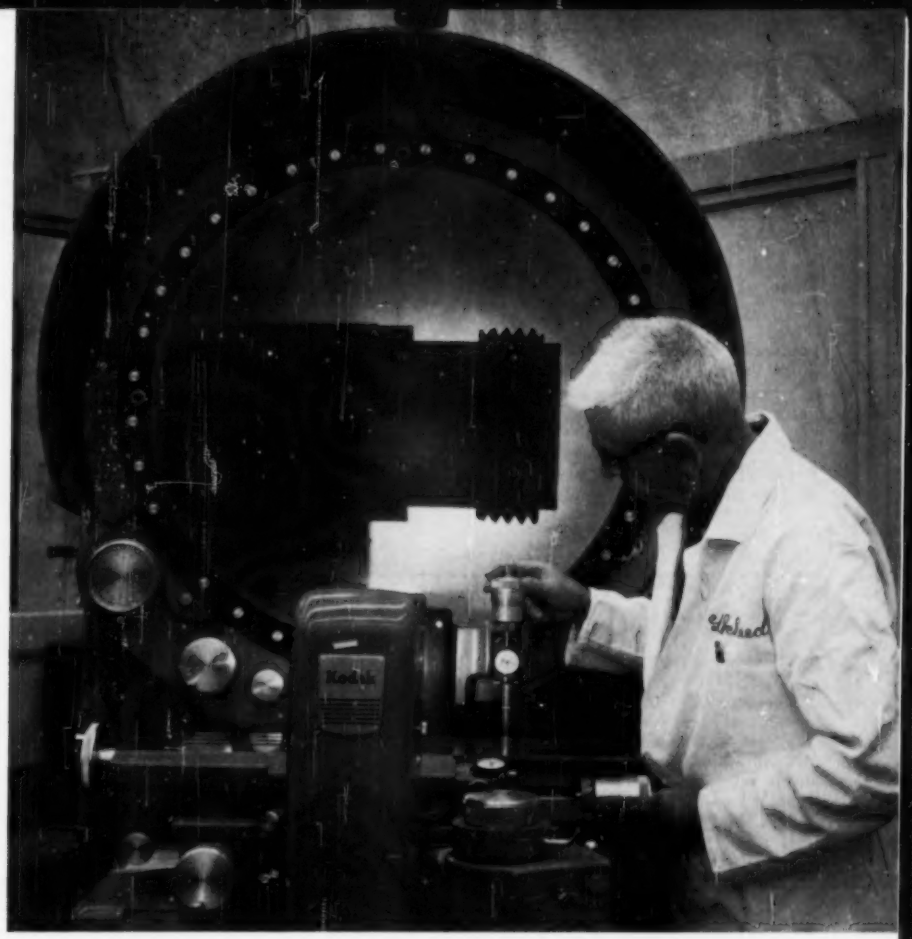
(right) Checking accuracy of machine threads on a 30 inch magnification contour projector.

Nation's first successful re-entry tests were conducted with Lockheed X-17.



Optical gauge determines measurements within 5 millionths of an inch.



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calibration of voltages greater than 100

ports the lower end of the thermometer and the capillary melting tubes so that test substance and thermometer bulb are both at the same height. In the steel cabinet is a transformer, controlled manually by a knob, that can be set to a pre-determined temperature. By a preliminary test at rapid heat, the melting point range can be found. Then the actual determination can be made by rapid heating to within five or ten degrees of the melting point, and by reducing further temperature increases to one or two degrees per minute. Price of the melting point apparatus is $290.

★ ★ ★

P-1-9—The new G-S Corrosion Test Cabinet features developments to improve test conditions and results for laboratories and metal finishers. The new cabinets are either Stainless or mild steel, all welded, Epoxy lined, noncorroding, and rust proof, and uniformly heated throughout by full coverage water jackets on all four sides and bottom. This eliminates all danger of uneven heating and secondary galvanic acceleration of corrosion. Maximum test heat is 150°F. and all temperatures are held plus or minus ½°F. A removable plexiglass transparent lid enables the operator to observe tests in progress without opening the cabinet, interrupting the process, or disturbing the specimens. Cam-type, non-fastening, gravity "hinges", front and back, provide for easy manual opening of the lid from either direction or for lifting off the lid entirely. The cabinet is equipped with a removable salt reservoir and cover for Salt Fog, Humidity, and Corrodkote testing. Important "optionals" are Automatic Bubble Tower Liquid Level Control with Strainer, complete air compressor equipment, and a full kit of cabinet exhaust accessories.

★ ★ ★

P-1-10—The new model AG Ames air gauge permits accurate measurements to 1 millionth of an inch for checking inside diameters or dimensions, outside diameters or dimensions, and center distance of holes, regardless of hole size. It can also be used for checking roundness of O.D., and I.D., and blind holes on small precision parts. The meter of this new unit has high linearity and zero hysteresis. The dial of the meter has large graduations for fast, easy reading. If a permanent record of measurements is required, an electric recording unit may be added to the gauge. This unit will register on special sensitized paper, a permanent record of all readings made by the gauge. Zero setting can be obtained by using either a master or proper size blocks. Once the zero setting is made, a three-point contact enables the user to detect a 3, 5, or 7-lobe condition in centerless grinding. Ames engineers will assist in developing special contacts and fixtures to simplify the precise measurement of unusual or intricately shaped parts.

★ ★ ★

P-2-1—Rese Engineering, Inc. has announced the new Model 1080 Precision Voltage-Current Calibrator, the most recent addition to their line of specialized test equipment for the magnetic industry. Accuracy of the instrument is better than 0.3 percent, and it is a dual purpose instrument, operating either as a secondary standard of voltage, or as a comparator type calibrator. It has been designed to solve a wide range of calibration and amplitude measurement problems, where great precision is required. The 1080 delivers precisely calibrated positive or negative voltages from 1 millivolt to 100 volts, which are continuously variable through four ranges. The standard voltage is available either as a direct voltage or as a 5 millisecond level, repeated at rates of from 5 to 50 times per second. In operation, a pair of mercury wetted relay choppers are biased permanently ON, connecting output directly to the potentiometer tap, or are driven by the internal transistor oscillator—one shot combination to provide a periodic calibrated pulse output. In comparator type operation, Model 1080 calibrates positive or negative voltages from 1 millivolt to 1000 volts continuously variable through five ranges, or calibrates currents from 1 milliampere to 10 amperes, continuously variable through four ranges. In either case, or when operated as a voltage standard, the internal standard voltage is absolute. For the

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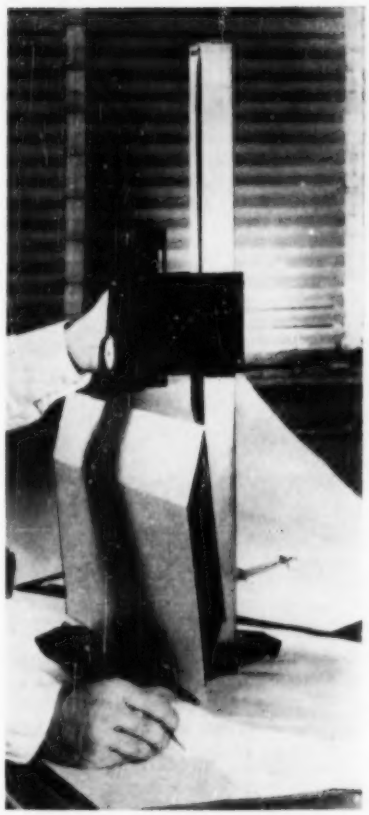
calibration of voltages greater than 100 volts, the unknown is first attenuated by a factor of ten to one, and is compared to the 100 volt scale. Currents are calibrated by converting to a voltage across the internal precision 1 ohm resistor. In addition to its many special uses, the 1080 is also useful as a general purpose calibration instrument in digital computer and other electronic laboratories, where it is used to establish accurate d-c power supply levels from 1 millivolt to 1000 volts, and as a general laboratory secondary voltage standard.

★ ★ ★

P-2-2—Because of the pressing need within their own organization, engineers at Consolidated Aircraft Products invented and patented the Multi-Mike, a micrometer caliper to measure widths of grooves and lands, chiefly in interior sections where no other gage can be used. After successful use in its own plant, Consolidated now offers this new micrometer which measures both internal and external cuts and grooves and determines groove locations. The unit is 8⅞ inches long with a standard micrometer type head. Two discs, each 0.547 inch diameter and 0.025 inch thick, ground and lapped, form the jaws or measuring surfaces. Measuring capacity ranges from 0.050 to 1.050 inch for groove widths. In measurement of lands or widths between grooves, range is from zero to 1.000 inch. Applications include measurement of the width of "0" ring and retaining ring grooves, keyways, cylinder grooves, and lands. The unit can be used to measure groove distance from an external reference surface to a probe depth of 5¾ inches.

★ ★ ★

P-2-3—A simple, accurate test instrument, called the Hunter Carton Scorebend Tester, has been developed to measure the force required to "break-open" flat folded paper-board cartons. The instrument is designed to help carton manufacturers control production quality and eliminate rejects, and to enable users of automatic cartoning machines to specify cartons to a recognized standard and discover "tough" cartons before they can cause filling line slowdowns and stoppages. This inexpensive tester is designed to provide simple, one-man production testing with laboratory instrument precision. The tester employs a precision direct-reading force gage. The gage is column mounted to accommodate folding cartons up to 22 inches wide when flat. To perform the test, the flat carton is inserted on edge between the grooved and the notched compression head of the gage. The inspector then merely turns a knob to depress the gage and force the carton open. The indicator hand holds the maximum dial reading to show the actual opening force exerted. Upon release of the control knob, the gage returns automatically to the starting position and is ready for the next carton. When the force reading has been noted, the gage is reset by touching a release tab. The gage head is adjustable at any point on the supporting column and is locked in position during the operation by a knob-operated friction lock. Three models of the Scorebend Tester are available: Model CC-500 for forces ranging from 0 to 500 grams; Model CC-1000 for forces ranging from 0 to 1000 grams; and Model CCO-1 for forces ranging from 0 to 16 ounces. The only difference between models is the force gage with which it is equipped and all three gages are interchangeable on the standard test stand and mount. The Scorebend Tester weighs about 11 pounds and has an overall height of 25 inches. Price of the tester, which includes one of the three interchangeable gages, is $195.00. The other gages are available at additional cost.



★ ★ ★

New Literature Available

L-2-4—To better enable the nation's spectroscopists to keep abreast of rapid developments in the electrode field, United Carbon Products Co. has just published their new S-58 Spectroscopic Graphite Products Catalog. In addition to graphite rod and powder, a complete variety of preformed electrodes are graphically illustrated with large, clear specification drawings. Factors of density, hardness, electrical resistance, and tensile strength are all documented for ready reference. A custom electrode service is also fully detailed.

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3/32″ keyway	No	No	Yes
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The modest price of a 55-R set makes a worthwhile saving over the cost of larger sets. The life of a set of gage blocks is lengthened since fewer blocks are required to make up common dimensions. It is practical to assign a set to each of your toolmakers or machinists to eliminate time waste created by a group working from the same set. Call your local DoALL sales-service store for further information and literature, or write.

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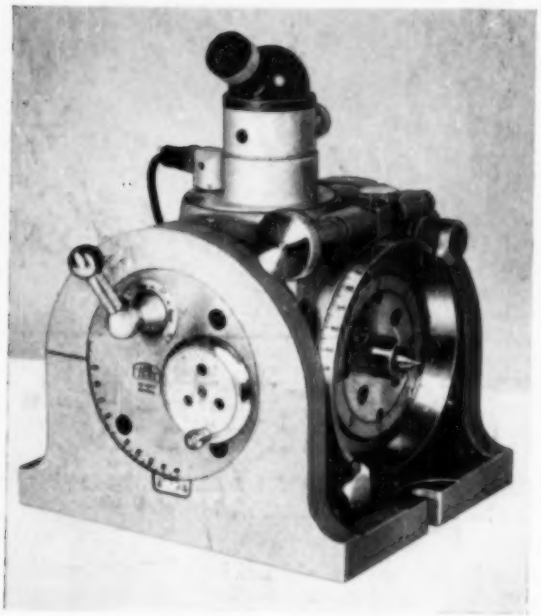
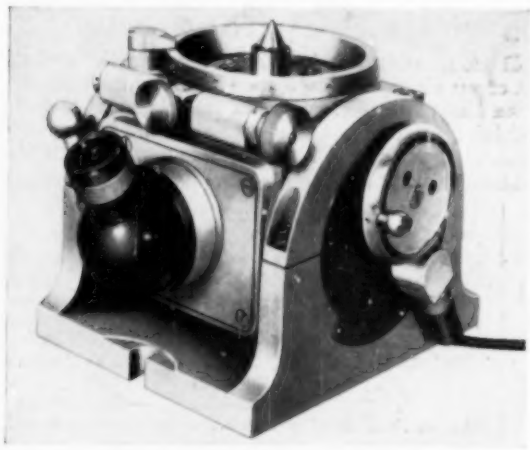


Large optical dividing head in horizontal position. Axis can be quickly changed to vertical.



Small optical dividing head in vertical position.

Latest models that offer outstanding features

The large optical dividing head is a universal testing and measuring instrument for circular scales and angles. It is used in high precision machining of cog-wheels, slotted and perforated discs, graduated plates, spline shafts and similar production parts. Suitable for grinding, drilling, milling and other operations.

The instrument is also suitable in testing for graduation defects and for checking the measurements of angle-measuring instruments, levels, cam plates, etc.

FEATURES: Graduated glass circle, with 360° scale, is rigidly mounted on dividing head shaft, and is not affected by the transmission system for shaft rotation. . . . Microscope with 63x magnification for angle readings has inclined eyepiece with a head that can be rotated in all directions—insures convenient reading, independent of the inclination of the shaft axis. . . . Fine and coarse adjustments are gearless and mutually independent. . . . An external 360° scale permits rapid setting. Overall height: 370mm. Center height of spindle 130mm. Area of base: 310x250mm.

THE SMALL HEAD

Designed especially for light machine tools in drilling, milling, grinding, etc., and its internal construction is the same as the large head. Its graduated glass circle is mounted on the dividing head shaft and is read with a 63x reading microscope. Has new anti-friction bearings for main dividing head shaft. Controls—coarse adjustment, fine setting of angles—can be easily arranged to right or left. Overall height 250mm. Center height of spindle 90mm. Area of base: 220x180mm.

Write for literature

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